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THE PSYCHOLOGICAL REVIEW.

VISUAL ILLUSIONS OF DEPTH.

BY PROFESSOR H. A. CARR,

The University of Chicago.

Visual illusions of movement in a lateral direction, *i. e.*, in some direction at right angles to the line of sight, have often been the subject of psychological description and experimentation. Comparatively speaking, we may say that the number of discussions of such illusions is legion. Illusions of distance are numerous and often commented upon in the literature dealing with the various criteria of visual depth. By 'illusions of distance' are meant those phenomena wherein objects appear to be located nearer to, or farther away from, the observer than they actually are, *e. g.*, the apparent nearness of a mountain peak in a rare and clear atmosphere. Illusions of *movement* in depth, *i. e.*, where the object appears to *move* nearer or farther away, are but rarely met with in the literature. Whether this be due to the fact that such phenomena are rare, have escaped notice, or possess but little psychological value, I do not know. Certain it is, however, that such illusions are rarely mentioned.

In an experimental attempt to evaluate the influence of brightness in the perception of depth, Ashley[1] found that a change in the brightness of an object mediated a consciousness of a third dimensional movement. Increase of brightness caused the fixated object to appear to move toward the observer, while a decrease in brightness produced an apparent movement in the opposite direction.

When two similar objects are binocularly combined and their distance apart is gradually altered while the observer attempts to maintain unity of vision, a pronounced third dimensional

[1] PSYCH. REV., Vol. V., p. 595.

motion on the part of the combined image is noticeable. This fact has been known for some time. By using a pair of compass points, one can give a ready demonstration of the influence of convergence and accommodation in the perception of distance. Dr. Bell has recently utilized this principle in studying the relative importance of accommodation and convergence.

While looking at a near object, a faint suggestion of forward and backward movements can be produced by successively intercepting the vision of one eye by a screen. The illusion is supposed to be due to a consequent alteration in the degree of convergent tension. A short account of the phenomenon is given by James.[1]

Third dimensional movements may be produced by either monocular or binocular eye closure, by finger pressure on the eyeballs, by a slight traction on the eyelids, and by forcefully opening the eyes to their widest extent. The presence, direction and extent of the illusory movements due to these causes vary with individuals, the position of the eyes in the socket, etc. The phenomena have been described and discussed by the writer in a previous article.[2]

In fainting spells, receding movements of the visual field occur with some subjects. Just preceding the loss of consciousness, perceived objects are seen to move backward to far distant positions. A similar illusion is said to occur during the loss of consciousness in etherization. James[3] quotes from M. Taine an account of an insane patient describing a similar receding illusion: "Objects grew small and receded to infinite distances — men and things together. I was myself immeasurably far away. I looked about me with terror and astonishment; the world was escaping from me. . . . I remarked at the same time that my voice was extremely far away from me."

Illusory movements in depth are voluntarily produced by some people. The gift is quite rare however. Eight such cases have been described by the writer in previous articles.[4]

[1] James, *Principles of Psychology*, Vol. II., p. 92.

[2] Carr, 'A Visual Illusion of Movement during Eye Closure,' PSYCH. REV., Mon. Sup., Vol. VII., No. 3.

[3] James, *Ibid.*, I., p. 377.

[4] PSYCH. REV., Vol. XIII., p. 258, and Vol. XV., p. 139.

With these people the illusion frequently occurs involuntarily in their normal experiences.

In some experiments involving binocular combination of slightly dissimilar figures, Hyslop[1] found that the depth location of the different parts of the perceived object could be varied relative to each other by changes of the attention. This is similar to the customary illusions of reversible perspective which are also examples of depth illusions.

The above list of illusions represents those cases which the writer remembers having noticed in the literature. It makes no pretence at exhaustiveness, nor at systematization in a general explanatory scheme. Given the possibility of such a variety of these illusions under *special* conditions, it would seem that some of them should also occur with some people in their everyday experiences. With this idea in mind, the writer made inquiries of the members of his classes in psychology for all cases of third dimensional illusions occurring at any time during their life. All persons responding were interviewed and subjected to a thorough cross-examination on the nature and conditions of the phenomena reported. Sometimes it developed that the occurrences described did not belong to the class of illusions desired, or else that the experiences had been so vague, fleeting, or rare, that the observer's memory of the phenomena was too indefinite and hazy in character for a trustworthy account. Such cases have been eliminated; all of the accounts given below represent cases where memory was definite and precise on the points mentioned. Each account represents all the illusions of this general kind which the observer can remember having experienced at any time during his life, with a general expression as to their frequency of occurrence, their nature and conditions.

In a series of classes comprising 350 students, I found 58 persons who have experienced involuntary depth illusions at some time of their lives. Five of these persons also possessed complete voluntary control over the phenomena and their experiences have been described previously. Of the 53 persons with whom the illusion only occurred involuntarily, I

[1] *Mind*, Series I., Vols. XIII. and XIV.

have been able to obtain detailed descriptions from 48, and these cases form the subject-matter of the present paper. Since the illusions have occurred involuntarily, any experimental investigation of the phenomena has been impossible. There is no uniformity in these experiences as regards their nature or conditioning circumstances. Hardly any two are exactly alike in all of their features. An attempt will be made to convey an adequate conception of the illusions by classifying them on the basis of a series of rubrics, giving detailed descriptions for purposes of illustration. In conclusion the significance of the illusions in regard to the perception of depth will be considered.

1. *Character of the Illusion.* — The illusion may belong to one of four types: (*a*) An illusion of pure distance. The objects appear to be located at varying distances from the subject but no movement is perceived. An object is first seen at its true distance, is next perceived close in front of the eyes, and is then seen at a very remote position. Twelve cases belong to this type (see VIII., XIII. and XX.). (*b*) Illusions of pure motion. Objects are perceived moving in a certain direction without any apparent change of location. They move but do not traverse space. This type is represented by two cases (see IX.). (*c*) Illusions of movement involving a change of location. The objects seem to move toward or away from the subject, both the motion and the change of location being distinctly perceived. Twenty-five persons reported this type of experience (I., II., IV. and V.). (*d*) Eight persons reported a combination of the first and third types. The object first *moves* away from its true location and is perceived in some remote position. After a short time the object suddenly *appears* back in its original location but this change of position involves no sense of motion (VI., XI. and XX.). The reverse case occurs in which an illusion of pure distance is succeeded by a return illusion involving the perception of movement (XVII.).

2. *Extent of Visual Field Involved.* — (*a*) Twenty-four persons reported that the illusion involved all objects in the visual field and that no contraction of the field was apparent. (*b*) With five subjects there was an invariable peripheral contraction of the field and the illusion involved all visible objects in

the central portion. The degree of contraction varies with the subject and with the different experiences in the same subject. The periphery is perceived as black, as a homogeneous light gray haze, or it may be a mere void without sense content (XI.). (*c*) Six persons were uncertain as to the periphery; some thought that it remained visible but were uncertain as to its participation in the illusion; others were uncertain as to its visibility. All were merely confident that the fixated objects were subject to the illusion (V. and XXI.). (*d*) With fourteen subjects the peripheral objects remain visible and stationary at their true position, while the central portion of the field participates in the illusion. It may occur that the fixated object moves in relation to other objects in the line of sight. As an example, we may cite an illusion that occurred only in church, wherein the preacher was perceived to move back through the wall and remain visible in this position for some time. The illusion occurred frequently and this striking feature caught the subject's attention (XIX.). With one subject, the central portion of the field remained stationary while only certain parts of the periphery participated in the illusion (VIII.). With one subject the illusion sometimes involved the whole and sometimes only a part of the visual field. This fourth type of experience is illustrated by the following account:

I. The illusion was noticed twice one year ago. It occurred both times under the same circumstances. The observer was looking down a street which ended a block away; a row of houses formed the background at the end of the street. The illusion occurred during day time and the weather was bright and clear. The observer was standing talking to and looking directly at a companion but a short distance away. Soon this person began to move slowly backward down the street until she reached the background of houses at the end, and then slowly came back to her original position. The movement in *both* directions was distinctly perceived. During the illusory movement there was no vagueness of outline or contour, no blurring or confusion of features; the person observed seemed distinct and substantial in character during the illusion. The subject felt that she continued to look directly at the person during the movement; she did not seem to be looking beyond her. The subject has noticed the confused vague appearance presented by persons when one looks beyond them, but in this case the person did not present this appearance. The perceived object moved in relation to surrounding objects; there was no movement of the visual field as a whole. The person decreased in size during the backward movement. She appeared about one half of her normal size when at the end of the street. The size increased during the forward return movement. This

change of size was very evident and caught the observer's attention at once. The perspective appearance of the street came out distinctly during the illusory motion, *i. e.*, the houses at the end of the street seemed to be smaller than the houses nearer by in proportion to their distance. The scene looked the way it would need to be drawn.

The illusion was at no time subject to voluntary control in any respect. At my suggestion the observer has since tried to repeat the illusion under similar circumstances, by voluntarily imagining such movements, but she was unsuccessful in obtaining the slightest suggestion of motion (also see VIII., XII. and XIX.).

3. *Kind of Images Involved.* — (*a*) With forty-two people the illusion involved normal perceptual objects. (*b*) There are five cases in which the illusion occurs in dreams. With four people the experiences occur only in dreams. Such a case is described in No. III. (*c*) There are three cases wherein hallucinatory images are involved. The following account represents the type:

II. The subject is slightly neurasthenic and hypochondriacal. During conditions of feverish semi-delirium, indistinct and confused masses of imagery emerge in the darkness and vibrate back and forth rather slowly between the eyes and remote positions. After a time the images disappear.

(*d*) One subject reports that the illusion sometimes refers to visual images under normal conditions. This experience (IV.) is described elsewhere in detail.

4. *Direction of the Illusion.* — Three types occur: (*a*) Illusion of increased distance alone. Objects move to, or appear at, more distant positions and then return to their normal location. Twenty-one illusions belong to this type (I., IV., VI. and VIII.). (*b*) Illusions of decreased distance. This type is reported by twelve persons. The illusion is confined wholly to positions in front of the real location of the object (X.). (*c*) With eleven subjects the illusion involves space on both sides of the real position of the object. The field may move forward close up before the subject's eyes and then back to the apparent distance of the horizon, whence it returns to its normal location (V., VII. and XVII.). (*d*) It is impossible to classify six cases in the above respect, inasmuch as the illusion occurred in dreams or involved hallucinatory images.

5. *Character of the Movements.* — (*a*) With seventeen persons the illusion is always vibratory, *i. e.*, the objects contin-

uously move backwards and forwards between two positions until the illusion is voluntarily destroyed or until it ceases of its own accord. The amplitude of these vibratory movements may vary from a few inches up to the full extent of visible space. The following account is illustrative:

III. The illusion occurs only in dreams. A confused dense mass of imagery slowly takes shape in the surrounding darkness, and begins to vibrate back and forth over an apparent extent of 100 feet. After four or five complete vibrations, the images disappear. The visible mass becomes larger as it approaches and smaller as it recedes. The experience has been repeated quite frequently.

(*b*) With twenty-three subjects the objects move to, or appear at, some definite position and remain there until the illusion is voluntarily destroyed by some means or until it disappears involuntarily. The following description will serve as an illustration:

IV. The illusion with this subject presents several features. All visual objects suddenly recede to the apparent distance of the horizon and remain in that position five to ten minutes. At the end of this period they return to their original position. This return movement is very slow at the beginning, but it gradually increases in rapidity, so that the latter phase of the movement is quite fast. If the subject closes her eyes while the objects are remaining at their distant position, she cannot even *imagine* those objects to be located except at this far distance. The illusion also occurs for visual *images*, when she is thinking of objects in visual terms either with closed eyes or under conditions of a high degree of abstraction from things of sense. These imaged objects behave as do the perceptual objects described above, with the exceptions that the backward movement is much slower, and the objects remain for a longer time at the distant position. The forward return movement is similar in rapidity to the perceptual case. The illusion also occurs in *dreams*, the movements being similar in character to those of the imaged objects.

In all cases the motion in both directions is an actual experienced reality. In no case is there the least voluntary control of the phenomenon. The subject is absolutely helpless as to initiating, stopping, or modifying the course of the illusion in any way. Objects and images decrease in size in proportion to the amount of backward movement and grow larger again on their return movement. The objects do not present any confusion of outline or blurring of features, nor do they become doubled. Persons were generally the objects of attention when the illusion occurred, and the subject maintains that their features remained normally distinct in every respect during the illusion. These experiences have occurred on an average of twice a year ever since she was in the upper grammar grades in school, a period of ten years. She cannot remember their occurring before this time, nor does she know of any sickness or abnormal experience at this time that may have been their cause. The illusion has occurred at all times of the day and with all conditions of illumination, but apparently only under conditions of a rather pronounced fatigue. The experience is always very unpleasant, giving that far-off lonesome feeling of being helpless, and isolated

from the world. She generally struggled desperately to bring back the objects to their natural position, but she always failed to move them in the least. With the movements of imaged objects with closed eyes, she can always tell before hand by some vague feeling that the illusion is soon to occur. She could not describe this anticipatory feeling except that it was disagreeable. There was no anticipation of the illusion except in this one case. The subject has never worn glasses nor had her eyes examined, though they seem to be very susceptible to fatigue.

(*c*) The illusion is irregular with five persons. The objects move to, or appear at, a certain position, remain there stationary for a time, undertake another excursion with a stationary period, and so on, until the illusion disappears. As the best description of this type, we give the following account:

V. The illusion has only occurred while reading. The letters suddenly move to some new position and remain there perfectly stationary for a time. They now jump to a new position, remain stationary, and again undergo movement. These irregular transitions in distance may persist during the entire period of reading. The direction of the jumps is irregular and the letters may move either in front of or behind their real location. The letters not only seem to *move* but they also look nearer or farther away. The letters become larger as they approach and decrease in size as they recede. No change in distinctness or vividness is involved. The illusion may occur shortly after beginning to read. Fatigue and steady fixation are not essential to its occurrence. The phenomenon occurred much more frequently in early life than in late years. At first it interfered with reading to a considerable extent but its disturbing influence was soon neglected. The subject has never experienced any trouble with her eyes. The subject could not remember with any degree of confidence as to whether the printed characters alone moved, or the illusion embraced the book and surrounding objects. She is under the impression that the illusion was confined to the letters.

6. The extent of the illusion varies markedly according to the subject, though it is more constant for any one person. With 23 persons the illusion is medium in length — 10 to 50 ft. The extent is less than this with eleven persons and greater with ten. The smallest illusions represent vibratory movements of but a few inches, while often the images move from the apparent position of the horizon clear up to the face. The rapidity of the movements also is subject to wide variations.

7. The frequency of these experiences varies between wide limits. Several persons have experienced the illusion but once. Others have experienced them on an average of three or four times per month throughout their lives. There is practically equal distribution as to frequency and infrequency of occurrence.

8. *Size of Objects.* — The nearest approach to uniformity in these experiences is in regard to the changes of size of the images in relation to the direction of the movement. (*a*) The usual law is that objects grow larger as they approach the observer and decrease in size as they recede. The change of size seems proportionate to the distance according to the law of perspective. Thirty subjects reported this fact. (*b*) Fifteen persons were uncertain upon this point. This is due to the facts that the extent of the illusion was very small, or that the illusion occurred so rarely or so early in life that their memory for details is defective. (*c*) With three subjects the objects became smaller as they approached the observer. This occurred only for those illusions which involved some patterned object. This is the usual result for binocularly combined images of regularly patterned objects, and hence these cases are not to be regarded as an exception to the above rule. (*d*) One subject reported that the images did not change in size. She is very positive in this regard and her statements are to be regarded seriously inasmuch as the illusion has occurred very frequently all her life and the movements were slow, realistic and of great extent. A detailed description follows:

VI. With this subject[1] the whole visual field moves backward until the objects reach the approximate distance of the horizon. The movement varies in rapidity for the different cases; sometimes it is extremely rapid and sometimes very slow, but as a general rule its velocity appears to be that of a brisk walking rate. The objects do not change in size, neither do they become blurred in appearance nor confused in outline. After this receding movement, one of three things occurs: (1) the objects remain visible and stationary at their distant position. This occurs but rarely; (2) the objects seem to move back into a light hazy cloud and disappear from view as though swallowed up by a dim veil-like mist. This distant background of haze remains in view during the continuance of the state; (3) all consciousness of visual space disappears at the termination of the receding movement; the subject becomes temporarily blind. This latter condition obtained in the majority of the experiences. The illusion terminates in either of the three cases by the objects suddenly appearing back in their original positions. They never *move* forward even in the case where they remain continuously visible; they always move away from the observer, but get back again without motion.

This subject is afflicted with hysteria and the illusion is an invariable accompaniment of an incipient trance which has been of very frequent occurrence

[1] This experience has been described more fully in the *Journal of Abnormal Psychology*, Vol. II., p. 260.

from the ages of six to twenty-two years. It has occurred at all times of the day and with all conditions of illumination in the room. The phenomenon has occurred only while the subject has been lying down for rest during a condition of marked fatigue and while the subject is in a state of complete mental and physical relaxation. These conditions, however, do not necessarily produce the phenomenon. The subject possesses no voluntary control over the course of the phenomenon. During the illusion she is always afflicted with a complete paralysis of all voluntary movements. The experience was always intensely frightful.

9. *Distinctness of Visual Objects.* — (*a*) No change in the distinctness of visual objects was reported by nineteen persons. These subjects are usually very positive in this regard. The images generally retain their normal vividness and realistic character. Persons are often the object of attention in these illusions, and it is maintained that every detail of their features remains in distinct view. Cases I., IV., V. and XIII. furnish illustrative examples. (*b*) Fourteen people were unable to give information on this point for various reasons: The mass of imagery was generally indefinite in contour and surface when it was of hallucinatory origin. It was impossible to answer the question in some cases because the illusion occurred during a condition of dizziness. Defective memory was responsible in six cases. (*c*) Fifteen people reported changes of distinctness of varying degrees. Theoretically, these changes may be due to an (1) imperfect ocular adjustment with a consequent blur of surface and contour, or (2) to a decrease of intensity resulting in mere vagueness. (3) An irregular decrease of intensity might result in a confusion of surface and contour which could not be discriminated from that resulting from imperfect ocular adjustment. It was extremely difficult to obtain from the subjects so definite and accurate a description of this aspect of the experiences as to allow a confident opinion in every case as to the essential conditions. Both conditions obtained, though the blur characteristic of defective adjustment seems to be the more frequent. The following cases illustrate each of these types:

VII. With this subject the illusion assumes diverse forms. Sometimes upon suddenly glancing at distant objects, they are seen located only a foot in front of her eyes. She does not first perceive them at their distant position and then see them move nearer; they are immediately perceived in front of her eyes, so close that she feels that she can reach out and touch them. They now begin to move away to their natural position, and they may occasionally move on

beyond it, this being followed by a return forward motion. When first seen, the objects are very blurred and the subject judges as to their real position by the degree of distinctness secured.

Again, she may first see the objects at what she regards as their true position, and they begin to move shortly after noticing them. They may also be first seen at their real location but are already in motion when first noticed. This motion may be either forward or backward in direction, will continue for some time, and then become reversed in direction, the objects returning to their true positions. On the return movement, the objects occasionally move beyond their real location for a short distance and thus undergo a second return. If the subject catches the objects on their first movement, she can voluntarily reverse the direction of motion; for example, if the objects are first seen moving forward, she can stop this and send them backward even far beyond their true distance. She knows of no conditioning circumstances which will explain why objects are seen moving forward in one experience and backward in another. She is also unable to describe in any way her method of voluntarily effecting this change of direction.

When objects are moving rapidly forward when first perceived and her visual attention is rather widely dispersed, she feels that the whole world is collapsing from every side toward her as a center, as if to crush her. All objects from above and below, from right and left, as well as those directly in front, are swiftly rushing toward her as a common focus, a condition which is described as being terrifying. Under these conditions she always is afflicted with the unpleasant sense of being crushed and overwhelmed in the onrushing avalanche of the universe.

In all of the illusions the movement refers to the *entire* visual field. The objects always change in distinctness, but she has never noticed any doubling. The maximum of distinctness is the criterion by which the real location of the field is determined. The size of the objects varies in proportion to their apparent distance from the observer. The illusion has occurred at all periods of her life, at any time of the day, and under various conditions of illumination. It has been more frequent out of doors during the daytime, and while looking at relatively distant objects.

VIII. The illusion is one of distance and occurs only during a condition of mental abstraction and steady fixation. The fixated portion of the field remains clear cut and distinct, and at its proper distance, while other objects in the field become faded and vague, and *appear* far away. For example, she has seen the knob of a door remain distinct and at its true position while the remaining portion of the door almost faded away and was perceived far beyond the plane of the knob. The illusion occurs very infrequently and is destroyed by head or eye movements.

The subject also experiences a similar auditory illusion which is rather unique. Sounds vibrate quite rapidly between their true location and some very remote position. The apparent loudness of the sounds varies with the distance, becoming fainter as they recede. The intensity variations are very striking and were described as 'pulsations' and as 'rising and receding swells of sound.' The illusion occurs only during a condition of mental abstraction. Sometimes she can produce the auditory illusion at will by throwing herself into the proper mental condition. The experience occurs involuntarily quite frequently.

10. *Essential Conditions of the Illusions.* — (*a*) With six persons, the illusion is apparently due to external conditions alone. For example, when two persons experience the illusion simultaneously, it is evident that the determining conditions presumably lie in the objective situation.

IX. The following illusion was observed but once, but by two persons simultaneously. It occurred in the hilly country of the Peekskill region. The time was about three o'clock in the afternoon of a bright sunshiny day in the spring, about a half year before this account was related to the writer. There were two parallel ranges of hills, the upper part of the more distant one being seen over the top of the nearer one. The two observers were walking along a valley road which ran parallel to and near the first range. Looking over this first hill they could see the green but hazy top of the second range set off strongly against the bright background of sky. Under these conditions the second range of hills and the sky background were perceived to be continuously moving backward, although the first range appeared stationary. The apparent motion was so real and striking in character and persisted so continuously that they both noted it independently and discussed the illusion at the time. Although the range kept moving backwards continuously, it did not appear to get any farther away; it seemed to remain at the same distance. After turning away their eyes and again fixating the distant hills, the illusory motion still persisted. It continued while walking along the road and persisted while this particular conformation of the landscape obtained. It was judged that the illusion was visible for at least ten minutes. Both observers had been in this particular situation before but had never seen the illusion until this time. My informant has good eyesight, does not wear glasses, and has never experienced any other illusory movements in depth.

(*b*) Internal conditions alone are apparently responsible for the illusion with twenty-four people. As an example the following case is self-evident:

X. The illusion occurs only during an incipient psychic epileptiform seizure generally induced by overeating. The seizure involves a feeling of faintness, dizziness and extreme muscular weakness. The illusion occurs in every such attack. Consciousness is confused, the visual field becomes blurred, hazy and misty so that objects are hardly recognizable. The whole field moves forward from three to five feet and keeps slowly vibrating between this position and its real location throughout the attack. Objects become larger as they approach the subject. Keeping the eyes closed is the only means of getting rid of the illusion. With the exception of the attacks the subject has enjoyed unusually good health. No eye troubles have been experienced.

(*c*) With three persons, the descriptions furnished no clue as to the essential conditions of the phenomenon. (*d*) The necessity of both internal and external conditions was evident with sixteen persons. It may be that the objective conditions are

necessary only because they invoke the central conditions which are the immediate causes of the phenomenon. The following account furnishes an illustration:

XI. The illusion occurs *only* while listening to some public speaker in a church or hall. It has been noted most frequently in church. It may occur either at night or during the day, but its frequency has been *greater* in the daytime. All of the peripheral field surrounding the fixated person becomes black. The size of the central visible portion varies in the different experiences. This visible portion now moves back to some remote position and stays there until the illusion is destroyed by rapid winking or eye movement. The fixated object now merely appears back in its natural position and the peripheral objects once more become visible. During the illusion, the visible objects become smaller but remain clear cut and distinct in every way. Often a reddish-yellow flame or halo is perceived to cover and surround the speaker as though radiating out from his body in every direction. (This peculiar effect was present in a similar experience with another subject. Possibly this phenomenon may be similar to the colored aura of theosophy.) This illusion has occurred quite frequently throughout the subject's life. A condition of steady fixation and thorough absorption in the speaker are necessary to effect the illusion.

11. *Nature of Objective Conditions.* — With eleven subjects the illusion occurs *only* while fixating some person. With eight of these, the fixation of some public speaker or singer in church, theater or large hall is an indispensable condition. No. XI. is an illusion of this type. The illusion occurs only while reading with two persons (see V.). Fixation of some checkered or regularly patterned object is necessary with three people. The illusion occurs more readily during the daytime with four persons and artificial lighting is essential with five people. The distance of the fixated object from the observer is of some influence upon the occurrence of the phenomenon in twelve cases, but this factor possesses no influence with fifteen persons. The direction of the illusion occasionally depends upon the distance of the fixated objects (XII., XIV. and XIX.). The 'clothesline illusion' was experienced by three people: While looking up at the line, it is perceived to move forward toward the subject, though the remaining objects in the field are stationary. The subject experiences difficulty in locating the line with her hands. With one subject the illusion was experienced only while observing some person walking; this illusion is of sufficient uniqueness to merit a complete description:

XII. The illusion occurred quite frequently during the period from ten to

fifteen years of age. It was first noted while observing a man holding his hands behind his back and walking towards the observer. The subject perceived the motion in the wrong direction, *i. e.*, the person appeared to be walking away from the observer instead of towards him. After this experience, the same illusion occurred involuntarily, although the person observed did not hold his hands in an unusual position. The reversal of direction might occur several times in the same experience. For example, a person was first perceived as walking toward the subject, but suddenly he appeared to be walking away, and this direction of movement was again supplanted by the forward direction, although the subject knew that the person observed was continuously moving in the same direction. Sometimes the conditions were such that the subject was confused as to which was the real direction of movement and which was the illusory one, until the person observed had come into a situation where the direction of motion could be inferred.

The subject developed voluntary control over this illusion, being able to see a man walk in either direction, or to change the perceived direction as often as desired. The subject was unable to describe his method of control except that he merely thought of the direction desired and the perceptual experience was modified accordingly at once.

The illusory movement was just as real and striking in appearance as a similar normal perception. The illusory motion made the person observed appear to be getting nearer or farther away as the case might be. These experiences occurred some ten years ago and the subject's memory was uncertain on many points which might have shed some light upon the phenomenon. The illusion only occurred while observing men walking either directly away from or toward the observer. The person must be from 150 to 400 feet distant and appear against an open background. The subject is under the impression that the illusion occurred either early in the morning or on dull days. He cannot recall whether it was necessary to fixate some definite portion of the body, *e. g.*, the moving legs. Since the period in which the illusion occurred, the subject has tried to initiate the phenomenon, but such attempts have been unsuccessful. With the exception of a slight astigmatism, the subject possesses good eyesight.

12. *Nature of the Subjective Conditions.* — (*a*) Steady fixation was essential with seventeen persons. In these cases eye movements destroy the illusion (see VIII., XI. and XIII.). Six of these people report that the illusion occurs only after a *prolonged* period of fixation. On the other hand steady fixation is not essential in thirteen cases for the illusion persists no matter where they look (see X.). The question of fixation is not pertinent when the illusion occurs in dreams or when the moving objects are hallucinatory images. With the remaining subjects it is impossible to determine from their accounts as to the necessity of steady fixation.

(*b*) Concentration of the attention, complete mental absorption or a dreamy mental abstraction are mentioned as essential

conditions by nineteen people. The writer attempted to discriminate between those cases in which there was a mental absorption or concentration of the attention upon the moving visual object, and those in which there was a mental absorption along ideational lines involving an abstraction from the visual experiences. It was generally impossible to be confident that the subjects grasped the distinction, and as a consequence we have grouped these cases together. In all probability the mental abstraction from things of sense is of major importance. Such a condition is illustrated in the following account:

XIII. The phenomenon occurred most frequently when talking to people. All objects in the visual field suddenly appeared much farther away than their actual distance. This apparent distance varied in the different experiences. Objects did not move away, but merely looked farther away. The objects remained clear cut and distinct in outline and detail; there was no vagueness, blurring, or confusion. The subject felt that she still continued to fixate the same object without eye movement in spite of its apparent greater distance from her. All objects looked much smaller when in this distant position. The illusion persisted until the eyes were rotated when the field again appeared in its normal position.

This phenomenon occurred very frequently during youth and its frequency has been gradually decreasing with age. It occurred at night and in daytime, and with all conditions of illumination, though it was more frequent with poor illumination. The subject lacks any direct mental control over the phenomenon; she experiences a feeling of utter helplessness and detachment from the world, a sort of hypnotic fascination, which she can shake off only by a voluntary rotation of the eyes. She was very much frightened at the first of these experiences, before she had learned how to discontinue them at will. The illusion comes on gradually but unexpectedly, and it takes forceful possession of her. A state of dreamy absent-mindedness and steady fixation is favorable to the oncoming of the illusion, and the subject has been able occasionally to produce the experience by voluntarily throwing herself into this mental condition.

The subject has never worn glasses nor had her eyes examined by an oculist. Neither have they ever given her any trouble.

(*c*) Fatigue is mentioned as an essential condition eleven times. The fatigue is generally quite pronounced, occasionally to the point of complete exhaustion. It is general, involving both mind and body (IV. and VI.).

(*d*) *Ocular Defects.* — (1) About 80 per cent. of the subjects do not wear glasses. The ocular conditions of the majority of these are unknown, though no eye troubles have been experienced. Six persons have experienced slight troubles and four

have had their eyes examined by oculists who pronounced them *free* from ocular defects (XVIII. and XXII.). (2) Of those wearing glasses, the illusion is as likely to occur with seven people while the glasses are worn as when they are discarded. One person reported that the illusion occurred only after the habit of glasses had been begun. The use of glasses entirely stopped the occurrence of the illusion with one person and largely minimized its frequency in another case (XX.).

(*e*) *Period of Life.* — (1) With twenty-seven people the illusion has occurred all through their life as far back as they can remember with practically the same degree of frequency for all periods (VII., XI. and XIX.). (2) With six persons the phenomenon has occurred too infrequently to allow of any statements as to the possible influence of any special period of life. (3) The influence of special periods is evident in fifteen cases. Six people report that the illusion has occurred in all periods but that its frequency has been much greater at some definite period (XIII. and XIV.). With nine persons the phenomenon occurred only within some definite period of life (XII.). With eight people the illusion ceased entirely or diminished in frequency at the end of childhood (13–14 years of age). Three people report no cessation of frequency until after the adolescent period (20 years). The illusion began after maturity with three subjects and at the beginning of adolescence in one case.

(*f*) Abnormal conditions are essential to the experience with eight people. These conditions include neurasthenia, fevers, attacks of faintness and dizziness, incipient delirium, and three cases of epileptiform seizures involving complete aboulia.

(*g*) *Miscellaneous.*— The illusions occur during a constrained eye position, while lying down, immediately after arising in the morning, and upon opening the eyes after some period of closure. Such conditions are rare and exceptional.

13. *Subjective Attitude toward the Phenomenon.* — Oftentimes the experiences are described as being terrifying or extremely disagreeable. This attitude generally occurs in those cases wherein the illusion is not in the least subject to voluntary control. When the field moves to remote positions, the feeling is one of utter helplessness, lonesomeness and isolated detach-

ment from the world. When the field moves up very close to the subjects, they experience the anticipatory feeling of being crushed and overpowered, or crowded and suffocated. Eleven subjects report that the illusion is always frightful and extremely disagreeable (IV., VI. and VII.). The majority of subjects report no unusual affective or emotional reactions to the illusion.

The feeling of subjective fixation of the objects without eye movement during the illusion is frequently commented upon by the observers (I. and XIII.).

14. *Voluntary Control.* — Cases of complete control over this illusion have been reported. By complete control is meant that the subjects can initiate and destroy the illusion, and alter the direction and the speed of the movement at will. In these involuntary cases partial control of the phenomenon occasionally occurs. (*a*) With twenty people no control at all is possible in either initiating, destroying or modifying the course of the illusion. The phenomenon suddenly occurs and persists for some time in spite of all attempts to escape it. Nos. IV., VI. and X. are illustrative examples. (*b*) Fourteen people can voluntarily destroy the illusion by some means. Of course it may be prevented by keeping the eyes closed until the temporary seizure is over as in No. X., but this can hardly be termed a volitional control. The means employed to destroy the illusion are eye or head movements, rubbing the eyes, or rapid blinking. In these cases steady fixation is an essential condition and the control is indirect, *i. e.*, destruction of the necessary conditions. Nos. VIII., XI. and XIII. are illustrations. (*c*) Five people can sometimes initiate the phenomenon indirectly by voluntarily producing the mental attitudes which constitute its essential conditions. These conditions are steady fixation and mental abstraction while listening to people (see XIII.). In all probability more people could influence the illusion by these means if the attempt had been made. (*d*) Six people can *directly* influence the course of the illusion by mental effort of some sort. Two of these cases have been described (VII. and XII.). The direction of the illusory motion is changed though the subjects could give no adequate account of their volitional method. Three subjects report that they can force the field back to its

true location by an effortful concentration of the attention upon the fixated object. In their own words, they look 'real' hard at the displaced images. The following illustrates this type of experience:

XIV. Backward movements occurred when fixating relatively near objects. The movement referred to the entire visual field. The objects moved away to a position two or three times the distance of their actual location. During the illusion her mind was in a state of abstraction and the objects remained at their distant position during the existence of this mental condition. The field moved back to its normal position as soon as the subject concentrated her mind strongly upon the fixated objects. During the receding movement objects became smaller, blurred and indistinct. She never noted that they became double. The illusion often occurred while reading, the book being the moving object. She was asked to converge behind a printed page and to note the blurring and the doubling of the print. The effect was described as similar to that occurring in the illusion while reading. Consequently, it is possible that doubling did occur in the illusion but that she failed to notice it. These illusions have been of frequent occurrence throughout her life, but they were more frequent during childhood. During the day their greatest frequency was in the evening as twilight came on, though she has experienced them in the bright sunlight.

The subject has also frequently experienced the forward illusion, *i. e.*, the case where the field moves forward to positions nearer than its real location, but she is not certain as to the conditions under which this type of illusion occurred. She related the two following experiences which are illustrative of the class: (1) While a child, she was playing in a barn and ran to an open door in the hay loft and looked down at the ground beneath, some ten or twelve feet distant. Soon the ground moved nearer, became larger and somewhat indistinct, until it appeared to be but a mere step down. The appearance was so realistic that she lightly jumped down with perfect confidence and as a consequence fell and hurt herself severely. She remembers with distinctness her surprise and astonishment during the fall at her disillusionment. (2) She was looking down over a steep precipice some two hundred feet high. The ground beneath at which she was looking was covered with large boulders and occasional shrubbery. These objects moved much nearer, became larger and blurred. She could voluntarily send them back to their proper distance by looking at them 'real' hard. This backward motion was perceived. She judged of the real distance by the clearness and distinctness of the images. This illusion has occurred several times under the same conditions.

The subject has noticed that her eyes become easily fatigued when observing distant objects. She is not conscious of strain or fatigue when observing relatively near objects. She has never worn glasses, nor had her eyes examined.

One subject reports that a receding illusion occurs under a condition of relaxation. The field is brought back to its normal position by a strong effort of will which involves a convergent movement of the eyes. Upon relaxing the effort, the receding illusion again occurs. By voluntarily alternating the effort and

the relaxation, the subject can make the field vibrate back and forth at will (see XVIII.).

The extent of movement possible is slight in some of the voluntary illusions previously described. Hence there is no marked line of division between the involuntary and the voluntary illusions. We have cases ranging all the way from no control whatsoever to absolute control.

15. In those experiences in which blurring occurs, in which the movements are large in extent, continuous and irregular in direction, and in which there is some degree of voluntary control, we find that the subjects generally rely upon the criterion of the 'maximum of distinctness' in judgments as to the objective position of the field. Nos. VII. and XIV. are illustrative examples. This feature was reported in one of the voluntary cases previously described.

16. *Causes.*— It is evident that we must assume the existence of several effective causes operating in various combinations in order to explain the diverse results. It is not our purpose to attempt an explanation of every particular illusion from *a priori* grounds. Rather we shall describe several illusions in which the effectiveness of known distance criteria is evident; we shall sketch the theoretical possibilities and limitations of these factors and seek to determine to what extent they may singly or in combination explain the various illusions.

(*a*) *Lenticular Disturbances.*— Lenticular disturbances are apt to be correlated with convergent changes, but we are interested in the effectiveness of this factor irrespective of the results of convergent changes which may or may not accompany it. That adjustments of the lens may be an efficient cause of these illusions is an assumption borne out by the previous studies on the voluntary illusions of depth. The evidence in favor of such a causal factor in the involuntary illusions is most pronounced in the following experience, the facts of which have been kindly furnished by Professor Colvin.

XV. Mr. O. informs me that the illusion occurred only at twilight, while he was resting in a room of average dimensions. At these times, objects at the farther end of the room apparently receded to a position three or four times their actual distance. The illusion was never experienced out of doors or in a bright light. Relaxation seemed to be an essential condition. Objects did not

become double. By an effort of will, the objects could be brought back to their normal location, though voluntary initiation of the phenomenon was impossible. The illusion was experienced frequently, in fact every time the above conditions were reproduced. He is under the impression that the convergence tended to change during the illusion.

The subject was increasingly afflicted with cataracts from twelve to twenty-four years of age, when he was successfully operated upon. The series of operations consisted of needling with subsequent absorptions. The illusion occurred only during this period, and most frequently during the three or four years preceding the operations. The phenomenon was less frequent after the first operation; it continued more or less until the lenses were entirely destroyed, but it has not occurred since that time, a period of twelve years.

The above facts are not as definite and conclusive in every particular as one might wish, but they indicate that the lens *in some way* is responsible for the illusion in question.

So far as *a priori* possibilities are concerned, the lenticular principle will explain the illusions with the following exceptions: (1) Those cases in which there is no blurring or confusion of the objects. This limitation is self-evident. (2) Those cases in which some object moves in relation to other objects in the field, when these latter remain in *distinct* view, *e. g.*, Nos. I., VIII., XII. and XIX. It is evident that the illusion should involve the whole visual field, or at least, that part well within the field of attention.

The fact of blur and confusion does not necessarily prove the existence of lenticular disturbances, for these characteristics may be the result of convergent changes or of an irregular decrease of intensity. The fact that the maximum of distinctness is often relied upon in judgments as to the proper location of the field is certainly more consonant with the lenticular hypothesis than with any other (VII. and XIV.).

(*b*) *Intensity Changes.* — It has been experimentally demonstrated that changes of brightness may mediate a sense of third dimensional movement. Backward movements result from a decrease of intensity, and an increase of brightness is interpreted as a forward movement. The influence of such a factor is evident in No. VIII. Here the fixated object is stationary, vivid and distinct. Evidently no defective ocular adjustment occurs. Peripheral objects *fade* away almost to the point of invisibility and recede to remote positions. In the auditory

illusion belonging to the same subject, the intensity changes accompanying the illusion are striking. Both illusions are for *increased* distance alone, which facts relieve us from the assumption that there may be an increase of the intensity beyond the normal. The assumption of a decrease of intensity is a logical one, inasmuch as the illusion occurs *only* during a condition of steady fixation and mental abstraction.

Granted that such changes may be an efficient factor, there are several reasons for supposing that these variations are present in many of the experiences. A decrease of brightness during steady fixation of an object is easily demonstrated by experiment. With monocular vision, the fixated object may totally disappear. Therefore there is good reason for suspecting the existence of this factor in every experience wherein steady fixation and mental abstraction are essential conditions. The fact of peripheral contraction of the field in six cases (see XI.) is an evidence of such decrease. In No. VI., the visual field at the end of its receding movement may totally disappear, or the objects may be swallowed up in a dim veil-like mist. Decrease of brightness is a natural result of defective accommodation, and there is a possibility that the blur or confusion so often reported is a result of an irregular decrease of intensity. A number of people use the terms 'hazy' and 'vague' as well as 'blurred' in describing these characteristics. Again it is illogical to suppose that a decrease of intensity does not occur because it is not noticed, inasmuch as it is possible that the intensity changes are not perceived *as such* simply because they are interpreted in distance terms.

So far as possibilities are concerned, this principle may be assumed as an effective factor with the following limitations: (1) It cannot explain those illusions in which the objects move to positions in front of their real location, for this would necessitate the unjustifiable assumption that the objects may become brighter than normal. (2) Such an explanation is not the most probable one in case of the regular vibratory movements, the illusions of patterned objects, and when the distance of the fixated object from the observer possesses some determining influence. (3) The factor possesses the greatest probability when

the field recedes and remains stationary at a remote position and when steady fixation, fatigue and abstraction are essential conditions.

(*c*) *Contraction of the Field.* — It has been suggested that the contraction of the field is a causal factor; that the field as a whole looks farther away because it has become smaller, on the principle that changes of size are often interpreted in distance terms. This hypothesis is plausible, but it is open to objection for various reasons: (1) It would be applicable to illusions of increased distance alone, wherein the whole visible field is involved and no confusion of images occurs. Vibrating movements would be difficult of explanation. (2) The peripheral contraction was reported by only six persons, though it may have occurred with a number of the uncertain cases. The application of such a principle is thus very limited on both factual and theoretical grounds. (3) One of the six persons (XVI.) reports that the illusion at first occurred in conjunction with the contraction and that the use of glasses prevented the illusion, although the phenomenon of contraction persisted. This fact disproves the hypothesis for this subject at least. (4) With a second person, the use of glasses greatly minimized the frequency of the illusion. This indicates at least that some other causal factor is present, and there is evidence that convergent changes are the effective agency in this case (XX.). (5) Another of the six cases (XVII.) presents features not compatible with the hypothesis; blurring and confusion of images are present and the objects move to positions in front of their real location. (6) Only three of the six experiences possess characteristics which are in no way *antagonistic* to the theory (see XI. and XXII.). There is some evidence that convergent changes are the effective factor in illusion XXII., and the other two cases *might* be explained by the convergent hypothesis. (7) Several people have informed me that they frequently experience a peripheral contraction during steady fixation, but that the phenomenon has never been accompanied by an illusion of depth.

The effectiveness of the factor has no experimental verification; it possesses factual and theoretical limitations as a general explanatory principle; there are a number of cases which demon-

strate its non-effectiveness; there are only two definite cases in which it has a potential validity, and these two illusions can be explained as readily in other terms.

XVI. The illusion with this subject occurs while listening to a speaker in a good-sized room, as a church or lecture hall, and after she has become rather absorbed in the discourse. It never occurs under other conditions. At first all objects in the visual field except those attended to disappear in blackness; these peripheral objects do not move but merely fade away. The speaker and the few surrounding objects well within the focus of attention remain visible, set in the surrounding mass of blackness. The size of this part of the field remaining visible varies with the different experiences. These objects now begin to move backward generally about fifty feet. After a short time the objects appear back in their normal position without movement. During the receding illusion, objects become proportionately smaller and very confused and blurred in appearance and contour. The speaker's voice sounds farther away, becoming weaker and harsh. The experience is decidedly agreeable, giving the subject a feeling of quiet restfulness and impersonal detachment from the world. There is no direct voluntary control over the phenomenon; it can be voluntary initiated to some extent by cultivating the proper mental attitude, an attitude which the subject cannot describe. However, this same feeling can sometimes be induced without the resulting illusion. The phenomenon has occurred in the daytime as well as at night. It began in early life as far back as she can remember. One such illusion per month represents its average frequency. The phenomenon persisted up to six years ago (19 years of age), at which time the subject began to wear glasses. Since then she has occasionally attempted to repeat the phenomenon by throwing herself into the proper mental attitude, but she has never been quite successful, though the illusion has often commenced in an incipient fashion. Even yet all objects in the visual field surrounding the object of attention readily disappear after a few minutes of fixation. The subject possesses good voluntary control of convergence; she can voluntarily converge either in front of, or behind, a wall ten feet distant.

XVII. The experience occurs while listening intently to a speaker. The periphery of the field becomes void of all sense content. The speaker *appears* far away, much smaller, and presents a blurred appearance. After some moments, the person is perceived to move forward, and become larger and more distinct. The forward movement often carries the object to positions in front of its true location. The illusion has occurred very frequently throughout life and under all conditions of illumination. Its frequency has been greater during daylight. A condition of steady fixation and mental absorption is essential, and the experience can be terminated by head or eye movements. The phenomenon can be voluntarily produced by effecting the necessary conditions of fixation and absorption.

(*d*) *Convergent Changes.* — Convergence is a known criterion of depth, so there is no reason for rejecting such an explanation. The presence and effectiveness of convergent changes is indicated by the illusions of patterned objects. Two of the three

subjects have noted a tendency for objects to become doubled during steady fixations. One of the persons can voluntarily produce the phenomenon by converging in front of the patterned object. These three cases belong to a special class.

(*e*) *Binocular Parallax.* — This factor is operative in a number of experiences, five of which will be described. It is closely associated with the principle of 'convergent changes' inasmuch as deviating eye movements are a necessary condition for its effectiveness. Consequently, we are concerned in the following illustrations in establishing the presence of convergent changes as a condition of the illusion, though not as the immediately effective factor. The relation of binocular parallax to the convergent changes will be depicted later.

XVIII. The illusion occurs while observing patterned objects and also while observing persons. The following description refers to the latter case. The illusion is one of increased distance alone, and motion in both directions is perceived. She cannot recall as to whether the periphery of the field participated in the illusion, although she is confident that it was vaguely visible. The objects remain stationary for some time at the end of the receding motion. *During* either the receding or the return movement, the images are confused and blurred, but clear up and become *normally distinct* and *definite while they are stationary* at either their real location or at some remote position. Objects become smaller as they recede. The illusion occurs during a condition of steady fixation, mental abstraction and relaxation. Fatigue is not necessary. While the objects are at a remote position, they can be voluntarily brought back to their real location by an effort of will which involves eye movement. This movement is not rotary, for fixation is not disturbed. The subject can distinctly remember the feeling of eye movement, but she cannot recall as to whether it was divergent or convergent in nature. The receding illusion again occurs when the effort is relaxed. By alternating the effort and relaxation, the field has been made to vibrate back and forth. The experience has occurred frequently throughout life. Her eyes have been examined by oculists and pronounced perfect. She has never noted any tendency in normal conditions for objects to become doubled while fixating them.

The subject's statements as to the presence of convergent movements and the blur with the subsequent clearing-up process were made without any suggestive questions on my part and she knows nothing as to theories of space perception. Evidently, no accommodatory disturbances occur because the images become clear-cut even in displaced positions. The fact of blur during the movement with a consequent clearing-up process while the field is stationary is explicable on the convergent hypothesis.

Granted that convergent changes of some sort condition the illusion, it is to be noted that the displaced objects do *not* necessarily become *doubled* or *blurred*. Ordinarily, doubling of images occurs in defective binocular adjustment because disparate retinal areas are stimulated. Thus the convergent theory will necessitate the further assumption that sometimes retinally disparate processes may allow of unitary vision, and it may be that the translocation in depth is due to this very fact, *viz.*, the unitary combination of images due to disparate retinal processes.

XIX. The illusion occurs only in churches, theaters and lecture halls, especially when the distance of the fixated objects is considerable (at least fifty feet). Only the objects of attention move; the periphery remains visible and stationary. The fixated objects also may move in relation to other objects in the line of sight, *e. g.*, a lecturer on the platform moves up to the wall behind him; in fact, sometimes the wall appears blurred and hazily transparent, and the person is perceived to move through the wall and to remain visible for a short time at some distance beyond it. The receding motion is quite slow; the return forward movement is rapid and it occasionally carries the objects past their real positions, this being followed by the necessary return. The moving objects become smaller and blurred during the receding motion. The stationary objects of the periphery remain the same size and are blurred to some extent especially around the edges. The illusion occurs involuntarily during a condition of dreamy abstraction and the objects tend to remain at their distant position during this condition. The illusion may be voluntarily terminated by blinking or eye movements. The moving objects often become *double* at the end of the receding movement; this condition has but a momentary duration; the images snap together and immediately start forward on the return movement.

This doubling always terminates the illusion immediately. Often the doubled images do not remain parallel, *e. g.*, the images of a person may be separated by a space of three feet at the top but only a foot at the bottom. The doubled images are blurred slightly, one always being much more blurred than the other.

The illusion has occurred quite frequently, as far back in life as the subject can remember, and it shows no sign of abatement in frequency of late years. It is experienced in the daytime as well as at night. A condition of dreamy abstraction with a rather pronounced ocular fatigue due to prolonged steady fixation seems to be an essential condition. Her eyes are not strong. Her left eye was forced from its socket when she was a child and for some time thereafter she was afflicted with convergent strabismus. Steady fixation is difficult and fatiguing. All objects more than twenty feet distant *tend to become doubled* homonymously when fixated, especially during conditions of relaxation, *i. e.*, the eyes normally tend to converge in front of the object.

The following facts indicate that the receding illusion is conditioned by a *convergent* movement of the eyes. There is a

normal tendency to converge in front of relatively distant objects (over twenty feet) during relaxation and steady fixation, and all these conditions are essential to the illusion. Fixation is difficult and fatiguing. The subject was once afflicted with convergent strabismus. The doubling that often occurs in the illusion must be due to convergence because it would be impossible for objects fifty feet distant to become separated a foot by a *divergent* movement of the eyes. The fixated object may move in relation to other objects in the line of sight, *e. g.*, the speaker moves through the wall behind him; this phenomenon is hardly explicable in other than convergent terms. Accommodatory disturbances are probably present inasmuch as the doubled images are blurred: this result may be due to the fact that they are perceived through the wall, but this is rather improbable in view of the fact that both images are not equally blurred. The stationary periphery is blurred, but this may be due to the doubling. Inasmuch as the doubling invariably destroys the illusion, it may well be argued that convergence can hardly be a cause. This conclusion is possible, but not necessary. As a temporary hypothesis, the following is suggested which is entirely consonant with all of the facts: that both convergent and accommodatory disturbances are present but that convergence is of major importance. The eyes converge in front of the fixated object so that disparate retinal areas are excited. Most of the visual objects become doubled and blurred and are normally located. Owing to the extreme concentration of attention, the objects in the focus are kept combined and a more remote location in depth is necessary to effect this result. The eyes may converge to such a degree that binocular combination is no longer possible and hence the images separate. This separation now stimulates a divergent movement of the eyes, which once more unites the images and brings them back to their normal location.

XX. In the following case, the illusion occurs while listening to speakers at some distance from the subject, and it involves the whole visual field. The field moves backward and remains at some remote position. The phenomenon is destroyed by sudden eye or head movements and the field merely appears back in its normal position. All objects become smaller. The periphery becomes *very* dim and blurred, but it does not totally disappear. The central por-

tion remains clear and distinct. Steady fixation is not a necessary condition. Mental abstraction is essential. The illusion occurs more frequently in the daytime. The period of greatest frequency was between the ages of eight and fourteen years. The subject is astigmatic and near-sighted. The use of glasses has greatly minimized the frequency of the experience. There is a marked tendency for all objects to become double during conditions of relaxation and abstraction. Tests demonstrated the existence of a divergent tendency while fixating near objects (less than ten feet), and a convergent tendency for relatively distant objects. Since these tests were made, the subject reported that she experienced a *forward* illusion while conversing with a person some five feet distant. In other respects the experience was similar to the receding illusion described above.

There is no direct evidence that convergent changes occur during the illusion, but there is proof that such changes tend to occur in the mental conditions essential to the production of the illusion. As in the preceding case, the backward illusion is associated with convergent movements, and in addition we find a *forward* illusion connected with the divergent tendency. Again, the periphery becomes blurred, but the fixated central portion remains clear-cut and distinct. Evidently no accommodatory disturbances are present.

XXI. This illusion is one of *distance* without any perception of motion. As to the periphery of the field, the subject has no memory either of its visibility or its participation in the illusion. The fixated object is always a person *at a distance* of at least ten feet. The illusion is vibratory. Objects appear on both sides of their real position, though the receding illusion is of the greater magnitude. The initial illusion is always a receding one, and the objects appear slightly in front of their real position only in the return illusion. Objects become smaller as they recede. The images are always blurred and generally they are slightly *doubled*. The tendency to double is always present throughout every illusion, and this tendency must always be resisted with effort. This effort is described as a muscular strain in the orbicular region. When the effort to maintain unitary vision is unsuccessful so that marked doubling occurs, the illusion disappears.

The phenomenon has occurred frequently throughout life. The only essential condition is a prolonged steady fixation of some person, involving a high degree of mental abstraction and concentration of the attention. The doubling tendency after a few minutes fixation is present in normal vision, *i. e.*, when the illusion does not occur. Continual effort is necessary to maintain unitary vision. This effort is the same as that described in the illusory experiences. Tests demonstrated that the tendency was convergent in nature, *i. e.*, resulting in homonymous doubling, and that it occurred for objects situated at a distance of more than eight or ten feet.

Again, we have doubling occurring *during* the illusion. Too great a separation of the images destroys the phenomenon. The

marked separation possible shows that the eyes converge in front of the objects. In normal experiences the eyes tend to converge in front of the fixated object when it is situated eight to ten feet distant. The illusion occurs only for objects at a distance of at least ten feet.

XXII. The illusion occurs while listening to public speakers or observing a play at the theater. The visual field contracts to about one half its size. The periphery becomes a light gray hazy mass, often suffused with a reddish-yellow light. The illusion is one of pure distance, no movement being perceived. The visible portion of the field alternates continuously between its true location and more distant positions. The change of location is instantaneous, without break of vision. Objects decrease in size in proportion to their apparent distance from the observer, but they remain normally distinct. The illusion has occurred but rarely and only within the last few years. Artificial illumination, a prolonged steady fixation, and a thorough mental absorption are essential conditions. Oculists have pronounced the subject's eye to be *free* from optical defect. Weakness of the external recti is responsible for a slight muscular strain. There is a strong tendency for fixated objects — even relatively near objects — to become doubled. This tendency is oftentimes very difficult to overcome. Tests demonstrated that this tendency is convergent in nature, a result which is consonant with the reported weakness of the external recti.

In the above experience we find associated a weakness of the external recti, a normal convergent tendency, mental absorption as an essential condition, a receding illusion and distinctness of the visual objects.

These five cases offer presumptive evidence in favor of the suggested hypothesis: (1) There is direct evidence as to the presence of eye movements *during* the illusion in three cases. (2) There is also indirect evidence in four cases, inasmuch as there is a natural tendency towards doubling in the mental conditions essential to the illusion. Similar direct and indirect evidence as to the presence of eye movements during the illusion is furnished by one experience, a description of which has not been given. (3) In four cases the convergent tendency is associated with the backward illusion, and the forward illusion is once correlated with a divergent tendency. (4) A marked doubling tends to destroy the illusion in two experiences. (5) The images remain distinct with three persons. (6) Concentration of attention is necessary for the illusion, and it may be assumed that unitary vision resulting from disparate retinal stimulations may occur only under this condition.

This hypothesis makes two assumptions which may be regarded as questionable: (1) Whether unitary vision *may* sometimes result in case an object stimulates non-corresponding retinal areas, and (2) whether this unitary combination ever does involve an unusual depth location. The questions are mooted ones, but probably the best opinion is in favor of the affirmative. The writer subscribes to the affirmative position for two reasons: (1) The main motive underlying the contention that unitary vision involves only corresponding retinal points in a strict mathematical way, seems to be the attempt to standardize visual processes according to mathematico-optical ideals. (2) The assumptions are supported by several experimental facts. The experiments described by Hyslop[1] best serve our purpose. If the two large circles in Figs. 1 or 2 are combined by divergence or convergence so that they fall upon corresponding retinal areas, it is evident that the two smaller circles cannot stimulate corresponding areas because they are not concen-

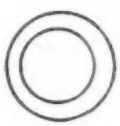

FIG. 1.

FIG. 2.

tric with the larger circles. Yet it is possible to combine simultaneously in unitary images both the larger and smaller circles, at least so far as casual perceptual results are concerned. Again, it is to be noted that divergent combination of Fig. 1, and convergent combination of Fig. 2, produce the following results: The similar smaller circles stimulate non-corresponding areas in such manner that normally they would be perceived as *homonymous* images, and that the unitary image is located *behind* the plane of the large circle, the degree of its remoteness being conditioned by the extent to which the stimuli deviate from corresponding points. Convergent combination of Fig. 1 and divergent combination of Fig. 2 give these results: The smaller circles, if not combined, would be perceived as *heteronymous* images, and their unitary image is projected *forward*

[1] *Mind*, Series I., Vols. XIII., p. 499, and XIV., p. 393.

in proportion to the degree to which their stimuli deviate from corresponding areas. Thus a forward depth displacement results from uniting heteronymous images, while a backward displacement is correlated with the unitary combination of homonymous images. We are interested for the present in these results merely as *statements of fact*, and not in their explanation. Such factual results in this experiment are exactly identical with the assumptions underlying the explanation of the above illusions: Convergence results in a backward illusion, but convergence produces homonymous doubling. Divergence is associated with the forward illusion, but divergence produces heteronymous doubling. The maintenance of unitary vision, under these conditions which usually result in doubling, is secured by a depth displacement whose direction depends upon the kind of doubling and whose amount corresponds to the size of the deviating eye movement.

It is to be noted that the eye movements *per se* are not the efficient factor in the above explanation. In the ordinary conception as to the influence of eye movements, divergence is correlated with a remote position of the field, and convergence locates the objects nearer to the observer. Either the tactual-kinæsthetic sensations resulting from the movements, or the binocular innervation of the act is supposed to influence the spatial character of the percept. In our explanation the eye movements are essential only because they create the necessary conditions for the operation of the effective principle, *viz.*, the unitary combination of disparate spatial processes. This principle is practically equivalent to what has been termed elsewhere[1] for want of a better expression the 'binocular parallax.' There is no intention of denying the efficacy of the convergent principle as ordinarily understood; it is to be noted, however, that the binocular parallax is effective in the above illusions, although it is spatially *antagonistic* to the supposed effects of convergent movements.

One further possible interpretation must be considered. It may be supposed that the eye movements are so slow as to be unnoticed. Being ignorant of the eye movement, the subject

[1] *Ibid.*, PSYCH. REV., Mon. Sup., Vol. VII., no. 3, p. 114.

fails to make allowances therefor, and hence he erroneously judges that the field is moving in a direction opposite to that of the eye movement. This principle has been used in the explanation of some of the lateral illusions of visual motion. I have attempted elsewhere[1] to show the fallaciousness of this explanation of the lateral illusions. Irrespective of its validity in those cases, the principle meets fatal objections in the third dimensional illusions: (1) It cannot account for the relative movement of different parts of the field, especially the relative movement of two objects in the line of sight (XIX.). (2) There is no 'ignorance' of the eye movements, as the theory presupposes, in one illusion (XVIII.). (3) Doubling and confusion of images are not always present, characteristics which must inevitably occur according to the theory. In fact doubling never occurs except in the two cases, and this doubling destroys the illusion. There is no confusion or blurring of the objects in three of the experiences (XVIII., XX. and XXII.).

There are practically no theoretical limitations as to the application of the binocular parallax principle. It is especially adapted to explain certain phenomena to which the other principles are not applicable, *e. g.*, the movement of the fixated objects without any change in their intensity or distinctness, the movement of one part of the field in relation to other objects, especially when the relative movement refers to objects in the line of sight, and a peripheral blur with clearness of images in the central portion of the field. The theory is directly supported by several other experiences which have not been described.

We stated previously that we were interested so far in the principle of the 'binocular parallax' as a mere statement of fact. The prevalent theory of explanation as applied to the perception of solidity — the Hyslop circles — is stated in motor terms: As a matter of fact the combined smaller circles are located at that depth position upon which the eyes must necessarily converge provided the images are normally combined. The eyes are reflexly stimulated so as to combine slightly doubled images. The theory assumes, then, that this constant reflex strain, or tendency, of the eye to converge upon a given

[1] *Ibid.*, PSYCH. REV., Mon. Sup., Vol. VII., no. 3, p. 86.

point in order to combine the displaced images is the cause of their combination and translocation to that position. Several objections may be urged against this theory.

1. The motor strain translocates only the smaller circles. Logically it would seem that such a peripheral factor should effect all objects in the visual field. The assumption that it possesses a selective influence needs further explanatory consideration.

2. The translocation of the smaller circles varies in amount in proportion to the extent of eye movement necessary normally to unite them. The location of the images is constant in any particular case of combination. Hence the theory must assume that the degree of strain varies in different cases in proportion to the deviation of the smaller circles from concentricity, but that it remains constant in any particular case of combination. The latter assumption is extremely questionable.

3. The figures are not only translocated in depth but laterally, *i. e.*, they are moved together until they unite. This lateral movement needs additional explanation.

4. The eyes do not move in the direction of the translocating tendency because of the necessity of maintaining the combination of the larger circles. In fact there are two antagonistic tendencies present — one effective upon the smaller circles and one upon the larger. This fact emphasizes the essentially selective character of these motor tendencies.

Matters may be further complicated. Four pairs of circles may be used. Two pairs may be projected at unequal distances in front of the large circles. The third pair can at the same time be united behind the plane of the large circles. There must needs be three motor tendencies present, a divergent one and two convergent ones. The latter must vary in intensity, for their effects are unequal. Granted that there may be two antagonistic tendencies each effective upon only a certain part of the visual field, yet the assumption of two simultaneous motor impulses of the same directive character, but of unequal intensity and each operating upon only a definite part of the field, is somewhat exacting upon one's credulity.

5. The motor theory meets difficulties in its application to

the illusions described in this paper. The eyes involuntarily diverge beyond an object, and this object remains single and moves forward in proportion to the diverging movement. The theory posits a convergent tendency as the unifying principle. But a divergent tendency is also present greater than the convergent one, because the eyes actually diverge. According to the preceding section, it might be assumed that this divergent tendency is the unifying principle for the larger circles of the Hyslop figures. In these illusions, however, this stronger divergent tendency has no material to unite. The convergent strain unites the images, while the divergent tendency is functionless. How can one possess a combining function and the other not? What determines as to which one is to be functionally active? Logically why should not the stronger tendency prevail?

6. The assumption that the combined images are located at that position to which it would be necessary for the eyes to move in order to combine them normally is true for the Hyslop figure, but not for these illusions. If this were true, the combined images would be located at the actual position of the object and hence no illusion could occur. This is evident from Fig. 3.

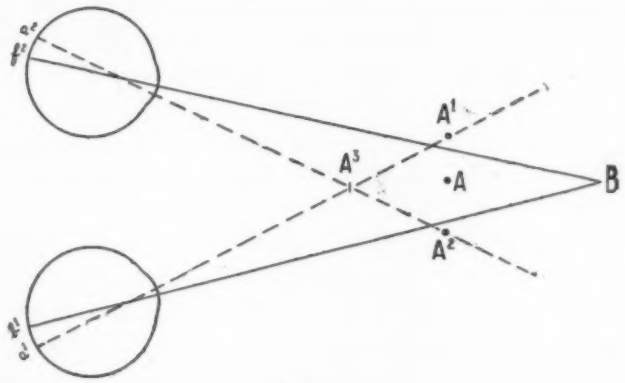

FIG. 3.

The eyes are diverged beyond an object A, so that the lines of sight intersect at B at a distance of six feet from A. A^1 and A^2 represent the heteronymous images of A as perceived in ordinary circumstances. Obviously a convergent movement

from B to A will normally unite these images; hence the convergent tendency toward A which is supposed to exert a combining and translocating function, should locate the images at A; the object would thus be perceived in its real position, and no illusion would be possible. As a matter of fact the visual object is located at the position A^3. This objection is fatal to the motor theory.

7. Such a reflex motor tendency to unite doubled images should be universal — occurring for everyone and at all times. This is true for the Hyslop figure, but not for our illusions. The combination of disparate images occurs for but few people and only under certain unusual mental conditions. The universality in the perception of solidity is probably due to habit. My point is this, *viz.*, that the effective principle, whatever it may be, operates only under certain unusual conditions.

In opposition to the motor theory, I wish to suggest a hypothesis which is free from the above objections. It involves two assumptions: (*a*) That the position of monocular images along the line of sight is variable, that an image may be perceived at slightly varying distances from the eye. In support of this contention we know that monocular judgments of distance are much more variable and inaccurate than those of binocular vision. (*b*) Some of these variable determining conditions are mental and central, *i. e.*, are not due to motor adjustments. The nature of these I do not presume to describe. That such mental conditions as extreme mental absorption and concentration of attention should influence monocular depth perceptions is not at all improbable.

The application of these assumptions to the illusions is simple. We have found that the combination of heteronymous images involves a forward displacement. Lines drawn from heteronymous images to their corresponding eyes intersect in front of the position of the object (Fig. 3). Under certain conditions the monocular images A^1 and A^2 are shifted along their lines of projection. If shifted forward sufficiently, they are perforce united. On the other hand, when homonymous images are projected backward, provided the lines of projection do not diverge beyond the parallel, they become spatially combined. No separate uniting mechanism need be postulated.

Inasmuch as the conditions determining the shift along the lines of projection are assumed to be central, they may well be selective upon the visual field, and different parts of the field may be translocated in different directions or for diverse distances. It may be objected that the images may be shifted in the wrong direction along the line of projection. This is true. In other words, the principle is not universal — a characteristic in which it agrees with the facts. The combination will occur only under unusual mental conditions — habit in the case of solidity, and extreme mental concentration upon the object with the above illusions. The fact that both images are shifted simultaneously in the same direction supports the contention that the determining conditions are central and mental.

The projection theory as outlined above readily explains these illusions of depth, a phenomenon which cannot be adequately accounted for in terms of the motor theory (Sec. 5 and 6). The sense of solidity, as typified by the combination of the Hyslop circles, may be explained as readily in terms of one theory as of the other. The projection theory, however, is free from the objections urged against the motor hypothesis, *viz.*, (1) that the effective factors must be spatially selective; (2) the necessity of assuming a number of motor factors working simultaneously, but which may be unequal in strength and antagonistic in direction, and (3) the efficiency of such factors only under unusual mental conditions.

To summarize, we have found direct evidence as to the efficiency of several factors governing depth, and we have sketched the theoretical limitations of each principle. These factors may operate singly or in various combinations. The principles have been derived from a consideration of a few specific cases, but so far as *a priori* possibilities are concerned, any illusion (with a few exceptions) *may* be explained by some one, or some combination, of the above principles. The majority of the illusions furnish no direct and unambiguous evidence as to the nature of the causal factors. If it be granted that all illusions are due to some of the above principles, there is evidence as to the probably effective factor in many specific cases. (1) The binocular parallax seems to possess the greatest potential appli-

cation. Such illusions as I., V., VI. and XI. are probably to be classed under this heading. (2) Lenticular changes are second in the extent of their application as an explanatory principle. Illusions VII., XIV. and XVI. find their probable explanation on this hypothesis. (3) Intensity changes seem to have some degree of applicability but apparently such a factor is generally operative in conjunction with other factors. (4) Convergence is probably limited to the three illusions of patterned objects. (5) The contraction of the field possesses a doubtful validity but, granted that it has some influence, its application is limited. (6) The illusions occurring in dreams and abnormal psychic attacks, especially when they are rhythmic in character (II., III. and X.), are probably due to motor disturbances and hence may be assumed to be conditioned by convergence and lenticular changes. (7) Those experiences which were classed as due entirely to objective causes (IX.) cannot be explained in any of the above terms. Illusion XII. also presents difficulty to any of these theories.

There is no intention of denying the possible efficacy of other causal factors in many of these illusions. The discussion has been purposefully confined to those factors for whose functional presence there is some direct factual evidence.

17. *Peculiar Phenomena.* — So far we have discussed the illusions from the standpoint of their spatial significance, — the factors determining depth location. Many other characteristics, such as the direction, kind, extent and rapidity of the movements, kind and distinctness of images, extent of visual field involved, etc., are readily explicable and need no further comment. Several features, however, deserve additional explanatory notice.

(*a*) Twelve experiences are illusions of pure distance, no movement being perceived; twenty persons experienced both movement and change of location; with eight persons the first and second types alternate in the same illusion, and two subjects experience pure motion. As a rule the subjects were very positive in regard to these points, the writer took pains to describe and illustrate very carefully these different possibilities, and the distinctions are easily comprehensible. As a consequence there

is little doubt of the validity of the distinctions in the main. The differences can hardly be due to the kind of space factor involved. For example, five experiences were explained by the principle of binocular parallax; two of these are illusions of pure distance; movement and change of location are experienced by two persons, and there is an alternation in one case. It may be assumed that the perception of movement and change of location is the normal experience but that the motion is not perceived when the spatial changes are either extremely rapid or extremely slow. When the objects remain at some remote position and the illusion is terminated by eye movements, no motion is perceived in the sudden return illusion. In illusions of pure distance the objects as a rule jump instantaneously from one position to another and remain stationary for a time (XXII.). In a few cases my notes furnish no clue as to the rapidity of the spatial changes. When motion is perceived, however, the movement is generally of a moderate rapidity. On the whole this theory furnishes the best explanation of the phenomena.

(*b*) The relation between the size and distance of visual percepts is a complex and variable one. When after-images, entoptic phenomena and combined images are projected at various distances from the observer, their size varies directly with the distance. This result was obtained in the three illusions of patterned objects, a result that can be obtained by voluntary binocular combination. In the majority of the illusions, the size varied inversely as the distance. This result seems to belong to the principle that when the object is known and the distance is wrongly perceived, a correction of size is made, because habitually distant objects appear small and near objects appear large. The absence of any change of size in the one illusion seems to be an anomalous result.

In conclusion, we are cognizant of the weaknesses of such a method of treatment. The facts are open to suspicion because of possible errors of memory, the incompetency of the subjects for accurate descriptions, and the influence of suggestive questions in eliciting a complete account of the phenomena. The uniqueness and frequency of the illusions should render memory more reliable than in ordinary experiences. Their number and

their comparative uniformity in many respects suggest that the general summary of the various characteristics must possess a large basis of fact at the very least. That each description is true in every particular is hardly credible. Necessarily the generalizations as to the space factors can hardly possess a validity equal to those derived from well controlled experiments. The conclusions as to the criteria of depth possess a suggestive and confirmatory value. The experiences do support the general proposition that the relation of the various factors governing judgments of depth especially in respect to their functional efficiency, is very complex, and probably subject to marked individual variations, — a conclusion which has been urged in the previous articles cited. These experiences are also interesting and valuable from the standpoint of human nature. The facts that they are so striking, so real in appearance, so antagonistic to the customary behavior of the visual world, so frequent in early youth — a period of imaginative susceptibility — and often so frightful, lead one to suspect the possible influence of such experiences in the development of more serious mental disorders.

MUSCLE-READING : A METHOD OF INVESTIGATING INVOLUNTARY MOVEMENTS AND MENTAL TYPES.

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I.

Recognition of the existence of involuntary movements, whereby a fit reagent may receive information of various sorts, such, for instance, as the whereabouts of an object thought-of or knowledge of the nature of an action meditated-upon is now widespread. Investigation has shown that the information conveyed by such involuntary movements may be received by the reagent in various ways. He may, for example, receive it through contact as in muscle-reading, or through the ear or the eye as in the so-called mind-reading without contact. An inanimate object may be substituted for the human reagent and involuntary movements may manifest themselves in table-tipping or by the behavior of the divining-rod or of the planchette or they may be accurately recorded by the registration of them by means of the automatograph or other instruments. It has, further, been shown that animals will respond to such involuntary movements, using them as signals for the performance of various acts. Of the possibilities of such response, Herr Pfungst's [1] highly entertaining work on the famous calculating horse of Berlin must remain for some time the classic report.

In the following investigation, the involuntary movements of the subject were interpreted by contact, by the so-called method of muscle-reading. The nearest approach in purpose to the present investigation was found, however — after the tests to be recorded had been completed — in the above-mentioned work of Pfungst, in the section reporting laboratory tests upon involuntary movements.[2] The movements reported by Pfungst

[1] Pfungst, O., 'Das Pferd des Herrn von Osten (der Kluge Hans), ein Beitrag zur Experimentellen Tier- und Menschen-Psychologie,' 1907.

[2] *Op. cit.*, p. 77 f.

were interpreted visually — a method of reaction superior, for experimental purposes, to reaction through contact in that it makes possible graphic registration of the movements of both agent and reagent. The situation dealt with in the following paper was less defined than that reported by Pfungst, a condition which renders the results less capable of precise formulation. They have, none the less, their value. The emphasis in the two tests was different. Pfungst only incidentally touched upon the point wherein lay the special interest of the present investigation, namely, the relation between involuntary movements and the nature of the control process used by the subject in the endeavor to concentrate his attention. Pfungst's observations on himself and his reports from his subjects confirm in part the results obtained in the present tests and constitute by far the most acute analysis of the situation which the present writer has found in the literature of the subject.

The history of muscle-reading runs very briefly as follows: In 1874, under the caption of 'Mind-Reading,' it began its platform career in America spectacularly with the demonstrations of Brown. It yielded, within a few months, its crucial secret — its dependence upon the involuntary movements of the guide — to that acute observer and analyst, Dr. G. M. Beard.[1] In 1881, after a similar career in England, under the auspices of Bishop, it was a second time investigated with similar outcome by a group of English scientists, chiefly Croom Robertson, Romanes, Lankester and Galton. Since that time, skill on the part of operators and knowledge of their *modus operandi* have developed concurrently. A literature on the subject has developed; partly semi-scientific — a reassurance of the public bewildered by the dexterity of the latest platform demonstrator — partly scientific, in the form of reports on specific aspects of the general problem, such as thought-reading without contact.

Apart, however, from the general conclusion that mind-reading by contact or otherwise is possible because of unconscious or involuntary indications given by the guide who concentrates attention on a particular object or action, the following interesting observations have been made.

[1] Beard, G. M., *Trance and Muscle-Reading*, 1882.

Relative to the muscle-reader himself it has been shown that ability in this line is not confined to a few particularly gifted persons, but is a general ability dependent upon practice for development,[1] although Beard questions the possibility of children under fifteen or adults over fifty becoming skillful in the art.[2] Neither do men who are adepts show when tested more than normal acuteness in tactual discrimination.[3] Emotional excitement, incident to public exhibitions if successful at all, and all conditions that induce a semi-hypnotic state in either reader or subject facilitate the reading.[4] The reader is often as unconscious of his method of reading as the guide is of his movements, although an intelligent reader usually grows sophisticated in time.[5] The degree of expertness the mind-reader may acquire is extraordinary. The precision with which he identifies one small object among many — selects, for instance, one pin among a dozen, or identifies a word or letter chosen at random from a large volume — is surprising.[6] Moreover, the action thought-of may be highly complicated without the reader being baffled thereby. Again, the tests may be successfully performed if indirect contact by way of a wire or other rigid connection be substituted for direct contact. Or between the guide and the reader one or more persons ignorant of the object selected may be placed, provided that the human chain thus formed be a rigid one. Moreover, contact may be done away with altogether and the reader be guided by the movements of the whole body of the guide or even by the sound of his footsteps as he moves with him.[7] This last-mentioned method of guidance by way of auditory indications suggests the later work

[1] Beard, *op. cit.*, p. 20, p. 36 (quoting Romane's Report on 'Thought-Reading' in *Nature*, 1881); Laurent, L., 'Les procédés des liseurs de pensées,' *Jour. de Psychol.*, 1905, II., p. 486 f.

[2] Beard, 'Physiology of Mind-Reading,' *Pop. Science Monthly*, X., 1877.

[3] Beard, *Trance and Muscle-Reading*, p. 34 (quoting Romanes's report).

[4] Beard, 'Physiology of Mind-Reading,' *loc. cit.*, p. 472; Laurent, *loc. cit.*, p. 486.

[5] Beard, *Trance and Muscle-Reading*, p. 14; Cumberland, S. A., *Thought-Reader's Thoughts*, 1888, p. 4; Gatchell, C., 'The Methods of Mind-Readers,' *The Forum*, XI., 1891, p. 201.

[6] In Pfungst's experiments, the amplitude of the movement which was the signal for reaction averaged one millimeter.

[7] Beard, 'Mind-Reading by the Ear,' *Pop. Science Monthly*, XI., 1877.

of Hansen and Lehmann, and the still later work of Laurent, on communication through involuntary verbalization.[1] Although the term 'muscle-reading' ceases to be appropriate when methods are so varied as to exclude contact, the principle of thought-reading through involuntary movement, whether interpreted tactually, auditorially, or visually, remains the same.

Relative to the guide in muscle-reading or thought-reading without contact, it has been shown that the value in this capacity of different persons varies greatly. Gatchell estimates that about one person in five among young people and one in ten or twenty among adults satisfy the requirements for a good subject who 'must be capable of mental concentration; he must exert no muscular self-control; he must obey his every impulse.'[2] A difference in the fitness of guides is usually attributed to failure on the part of certain reagents to meet the conditions of the tests Beard remarks that voluntary stiffening of the muscles delay. or renders success impossible and that knowledge on the part of the guide of the *modus operandi* has an inhibitive effect. "The best subjects would appear to be those who have moderate power of concentration and slight control over their muscular movements. Credulous, wonder-loving subjects are sometimes partially entranced through the emotions of reverence and expectation; with subjects in this state operators are quite sure to succeed.[3]

Romanes contents himself with reporting of the reagent in the English test as follows: "It was soon found that he succeeded much better with some of us than with others; so at the second meeting, in order to make a numerical comparison, he was requested to try two experiments with each of the four persons who were present. With Mr. Galton, Professor Robertson and Professor Lankester he failed utterly, while with myself he succeeded once perfectly and the second time approximately."[4] Cumberland, the expert English thought-reader,

[1] Hansen u. Lehmann, 'Ueber unwillkurliches Flüstern,' *Phil. Studien*, XI., 1895; Laurent, 'Les procédés des liseurs de pensées,' *Journal de Psychologie*, II., 1905.

[2] *Loc. cit.*, p. 199 f.

[3] 'Physiology of Mind-Reading,' *loc. cit.*, p. 467.

[4] *Trance and Muscle-Reading*, p. 31.

instances the involuntary or deliberate dishonesty of certain subjects who were either unable or unwilling to concentrate attention. Cumberland objects to the 'nervous' man as a subject. "It is with the determined man, the man with the iron will, the man who can concentrate his thoughts unwaveringly that I can succeed best."[1] And again, "With respect to 'women as subjects' it is quite an error to imagine that I achieve success more readily with women than with men. . . . Who make the best 'subjects'? is another question I am frequently asked, to which I can only reply, that whilst some persons actually are more suitable for experiments of this kind than others, every intelligent, thoughtful man who will act up to the conditions imposed upon him, is sure to be a good 'subject,' and that with such folk, I, in nine cases out of ten, should be successful. . . . Taking all in all, I have found the best 'subjects' among statesmen, diplomatists, mathematicians, literary men and all those engaged in active brain-work." Among distinguished men, Alexander Dumas is named by Cumberland as his worst subject, a fact attributed to Dumas' natural 'self-willedness.' Musicians as a class are cited as poor subjects; artists as somewhat better. Lawyers, physicians, and clergymen are described as furnishing some excellent material for tests but on the whole are found to be susceptible to certain limitations that make against success. Among subjects of different nationalities, the Germans are reported to offer the greatest number of good 'subjects' and Field-Marshal Von Moltke is named as the first among the best 'subjects.'[2]

Laurent[3] insists that success is inevitable if the guide is able to concentrate his attention and submits to the test in good faith. Failure on the part of the muscle-reader results from the involuntary dishonesty of subjects who are unable to concentrate attention for any length of time and from the voluntary trickery of those whose attention is concentrated on the idea of leading the reader away from the correct locality. Success is brilliant with honest guides of hysteric or nervous tendencies, whose obses-

[1] *Op. cit.*, p. 80 f.
[2] *Op. cit.*, Chap. X.
[3] *Loc. cit.*, p. 485 f.

sion by the idea concentrated upon leads to an augmentation of unconscious movements.

Pfungst[1] in his tests in the laboratory experimented upon twenty-five persons of various ages and of both sexes. He noted visually, controlling his observation by a graphic registration, the involuntary jerk of the head by which his subjects indicated the terminal member of a numerical series, thought of by them and tapped by the operator. Out of the twenty-five persons tested, only two (especially abstract thinkers) failed to react in the expected way. In only a few persons, however, was the head-movement very evident, that is, more than a millimeter in extent. Pfungst[2] found that excitement, 'warming up,' practice, fatigue, indisposition, the so-called 'Perseverationstendenz' and faith in results affected the outcome, in so far as these factors affected the subject's power of concentration of attention. If we omit the special conditions required for success when Hans, the horse, served as reagent, we may summarize Pfungst's statement of the conditions necessary for success in the tests tried by him as follows:[3] Capacity for strong concentration of attention for only a pronounced tension of expectation and will issues in such strong relaxation that the innervation-changes lead to an outwardly perceivable movement; lapse of self-control under the conditions of intense concentration; readiness of motor discharge toward the muscles rather than its expenditure in the production of vascular and glandular changes; maintenance of tension a sufficiently long time with relaxation at the right moment. It is concluded that all in all only a very few persons correspond completely to the type described. They were, says Pfungst, characteristically those who were otherwise reputed to be very impulsive and possessed of 'temperament.'

II.

For some years, the present writer has practiced muscle-reading with a deepening conviction that there are possibilities

[1] *Op. cit.*, p. 77 f.
[2] *Op. cit.*, p. 101 f.
[3] *Op. cit.*, p. 145 f.

in its use as a method of investigation which have not yet been exhausted. Her interest centered chiefly in determining if possible by its means a classification of mental types. It is obvious that this problem may be approached from the standpoint of either agent or reagent. The problems presented by the latter are, however, in this connection less interesting than those suggested by the agent or subject, although in mind-reading without contact undue sensitivity of sense-organ or abnormal passivity on the part of the operator must probably be assumed, and in complicated tests with contact there is involved a power of interpretation which may be dependent upon natural facility as well as upon extensive practice. In any case, tests upon many trained operators were out of the question while the writer as operator was herself able to handle many agents. The present investigation was then chiefly concerned with the problems presented by the agent or guide.

The fact that interest centered upon the psychology of the guide accounts for the detailed résumé of the observations that have hitherto been made upon the various types of subjects. A careful consideration of the reports given by experimenters shows two different emphases in explanation of the varying effectiveness of guides, an effectiveness measured by the tendency of subjects to react with involuntary movements and by the accuracy of such movements as an index of the direction of attention. Emphasis is laid, in the first instance, upon the need of concentration of attention and success with a given guide is cited as an evidence of his power to concentrate attention; in the second instance, less stress is laid upon this factor and the bearing of thought-reading tests upon automatic or hypnotic phenomena is emphasized.

Granting the contention of certain experimenters that failure with any subject is due either to the latter's inability to concentrate attention steadily, or to his unwillingness to contribute to the reader's success, and his maintenance, therefore, of self-control with consequent inhibition of natural expression, can muscle-reading be used as a simple device for determining relative to any given individual such temperamental tendencies as inability to concentrate attention steadily, constitutional combat-

iveness, power of control over involuntary movements? If so, muscle-reading has its place as a method in the investigation of mental types. Pfungst would add a third possibility of failure due to a tendency for the nervous energy liberated by concentration of attention to drain itself otherwise than through muscular innervation. He found, it will be recalled, certain abstract thinkers very inappropriate subjects. A varying readiness to motor expression might indeed be expected on theoretical grounds.

The first question then that phrases itself relates to the effect upon the outcome of the test of the subject's attitude toward it. Will scepticism as to the outcome or hostility toward the operator's claims or knowledge of his *modus operandi* result in inhibition of the involuntary movements that otherwise would result from the situation?

A second problem involves a consideration of the relation of concentration of attention to success, a determination, particularly, of the degree of concentration which favors success. An interesting development comes when it is discovered in the course of experimentation that the outcome of tests is varied by a change on the part of the subject in the method of concentration utilized. The question is now phrased: What relation, if any, exists between the sort of mental control exercised by the individual in his effort to concentrate attention and his value or worthlessness as an agent in these experiments? Has any one method of enforcing the attention a constant value? Or does the value of a particular method vary with the individual? If so, is there a constant variation dependent upon the sort of sense control utilized? Again, in that case, will the more or the less habitual method of enforcement prove the more effective? The question we are raising is the differing expressive or inhibitive motor value of differing sense forms of attention, a question that muscle-reading as a method of investigation seems peculiarly adapted to answering.

A third problem formulates itself in view of the fact that voluntary concentration of attention on the part of the subject is by no means as necessary to success as certain reports would lead us to expect. How are we to explain successes with dis-

tracted attention and those strange cases in which involuntary movements are an index to the past, not the present, direction of attention?[1] What bearing, if any, do these observations have upon the observations of Beard and Laurent that the most effective subjects for thought-reading tests are those individuals in whom automatic tendencies are increased by the narrowing of the field of consciousness through a trance-like condition brought on through undue suggestibility?

The outline of the report is now clear. After a brief discussion of the method used, in general, the writer will report in detail the course followed in an attempt to answer the above questions.

III.

In the tests, which have been under way for something over a year, the writer has served variously as operator, subject, and spectator. As operator (Dy), she has tested every agent, except herself. As subject — an unusually refractory one — she has introspected carefully her experiences under the test conditions. As spectator, she has been able to conduct certain experiments and make observations otherwise impossible. Her experiences as subject were, on the whole, the most interesting and enlightening.

In the tests in which the writer did not serve as operator, her place was taken by Miss Abby Drew (Dw), a college junior, who as a student of psychology had amused herself by developing skill in muscle-reading. As Miss Drew was, like the writer, a poor reagent, a profitable series of tests was that in which these two reagents worked with each other, tests which only after many weeks ended in success.

In all of the tests to be described, contact between operator and guide was made by way of the hands. The operator with her right hand touched lightly either the wrist or finger-tips of the right hand of the guide, or clasped the guide's right wrist with her right hand and touched the guide's right finger-tips with her own left hand. This is, apparently, the method of contact used by Cumberland, the English expert. Brown,

[1] Downey, J. E., 'Automatic Phenomena of Muscle Reading,' *The Jour. of Phil., Psychol., and Scientific Methods*, Vol. V., p. 650 ff., 1908.

whom Beard tested, pressed the back of his subject's hand against his own forehead and with his other hand touched the palmar side of his subject's hand. Laurent reports[1] that test-variations showed the best method of contact to be that in which the subject placed his hand between the shoulders of the operator. All of these methods were tried during the course of experimentation. Brown's method was discarded because of the fatigue that ensued from the strained position of the arm, a strain particularly evident when there was great difference in the height of operator and subject. Laurent's method proved to be excellent so long as general direction of movement was in question but it was found to be much less precise than contact by the hands when it came to identification of an object.

Most of the experiments reported were tried in the psychological laboratory of the University of Wyoming, a laboratory which consists of a double room, the outer section of which opens on a hall and staircase and is separated from the inner by a partition, the windows of which can be darkened with curtains. The length of the two rooms is about thirty-three feet; the width some fifteen feet. The outer room is equipped with four rows of opera chairs, six in a row, and with writing-desk, book-shelves, a swinging blackboard and radiator. The inner room is furnished with three tables, one extending almost the whole length of the south side of the room; the two other tables, much smaller, occupy the north section of the room. This room also contains two apparatus-cases and wide shelves running the north length of the room. Chairs and radiator complete the equipment.

The general procedure was as follows: The operator would withdraw into the hall and during her absence the subject would select and place in a position either exposed or hidden and in either the outer or the inner room, an object for identification. The operator would then be summoned; contact would be made at the entrance to the outer room; a stop-watch would be started; and the test was on. Sometimes, before movement, the operator would resort to a relaxation of the hand and arm of the subject; occasionally the whole body of the subject would be

[1] *Loc. cit.*, p. 488 f.

swung rapidly from side to side. With 'hard' subjects such relaxation was sometimes repeated during the tests. In the preliminary experiments the operator generally took the lead. Dy moved very rapidly and when successful achieved success, usually, in a very short time. Dw moved more slowly but with great accuracy. In the earlier experiments Dy always blindfolded herself carefully before entering the room and was under the impression that this blindfolding was necessary to success. It certainly contributed to her confidence and shut out distracting impressions. Later, she found it sufficient to close the eyes. Dw was confused by a blindfold and preferred merely to close the eyes.

A report of the experiment was made by the writer immediately at the close of each test. In the more complicated tests, these reports were supplemented by records kept by a spectator during the actual experiment. In many of the tests, for instance, the spectator reproduced on a map of the rooms, previously drawn to the scale, the exact course followed by the subject in placing and by the operator in finding the object.

Variations in method will be described in connection with the discussion of different problems. In general, but little attempt was made to produce brilliant or theatrical effects. It was not possible to estimate the actual expertness of the operators. Dy was, however, able to reproduce all of the feats mentioned by the experts, such as writing out dates of which the subject is thinking (contact by operator's left hand only), or the writing of several syllabled words (contact by right hand of operator); finding a book and identifying therein a word chosen at random; successfully locating an object although several persons ignorant of its whereabouts are placed between operator and subject; operating without contact when the subject moves near her. To succeed in these tests, Dy must work with 'fit' subjects. She had never tested herself in the location of an object at a great distance nor can she succeed without contact when the subject is some distance away. The writer has seen but one platform 'mind-reader.' Stripping his performances of irrelevant and theatrical effects, she could have reproduced his results with great ease. The most difficult part of

such an experiment, namely, the identification of the object after its general locality is found, was by this operator overcome by himself selecting or naming the object which was to be hidden. To repeat, for the purposes of the present test, precision was of more consequence than brilliancy.

The great defect of the method was the lack of an objective control of the subjective reports. Of course, in a measure, success furnished evidence of the initiative of the guide and of the expertness of the operator; but in the case of failure, complete or partial, it was impossible to determine absolutely whether the failure was due to defective concentration or defective motor impulse on the part of the subject or, rather, chargeable to the maladroitness of the operator. Objective control by way of registration of the involuntary movements was, however, in the present set of tests, out of the question.

IV.

A preliminary experiment involved the determination of the number of subjects with whom the writer would be able to operate successfully. To estimate the percentage of 'fit' and 'unfit' subjects for such a test, rapid tests of a great number of subjects, taken at random, were tried. Only those subjects upon whom the writer took notes at the time of test are included in the summary. Under such conditions sixty subjects were tested; forty in the laboratory as described above; twenty under slightly different conditions and in other surroundings. In the latter case, there were frequently several or many spectators present; in the former, few or none. In the case of fifteen of these subjects but one test was tried. The other subjects were tested two or more times. Forty-three of the sixty subjects were women or girls; seventeen, men or boys. In age, they varied from nine years to over fifty. The table summarizing results follows. By a partial success is meant a case in which the operator went to the article and then withdrew from it or explored in its vicinity without finally locating it.

Whole number of subjects tested, 60.

Number with whom completely successful first trial, 42 (70 per cent.).

Number with whom wholly or partially successful first or second trial, 56 (93.3 per cent.).

Number with whom failed after repeated trials, 2 (3.3 per cent.).

The subjects grouped according to sex give the following record:

Whole number of women and girls tested, 43.

Number with whom completely successful first trial, 29 (67.4 per cent.).

Number with whom wholly or partially successful first or second trial, 40 (93 per cent.).

Number with whom failed after repeated trials, 1 (2.3 per cent.).

Whole number of men and boys tested, 17.

Number with whom completely successful first trial, 13 (76.4 per cent.).

Number with whom wholly or partially successful first or second trial, 16 (94.1 per cent.).

Number with whom failed after repeated trials, 1 (5.8 per cent.).

The ease with which success was obtained, measured either by the time needed to achieve it or the amount of effort required on the part of the operator, varied greatly even with those subjects with whom success was achieved. About eight of the sixty subjects (including the writer, nine of those tested) would be described as particularly difficult to handle. The striking outcome is the great number of individuals indicating by involuntary movements the direction of attention.

Even in the case of the two subjects with whom the writer failed to succeed, momentary indications were given. With these two subjects six tests each were tried. The first subject was tested at the very beginning of the experimental series, at a time when the writer, unaware as yet of the difference in results introduced by variation in the method of concentration, failed to try the effect of a change in the control. The second subject was tested at a time of intense preoccupation, on the part of both operator and subject, with disturbing matters so that neither was in good condition for the test. It is not probable that these two

subjects would have proved, under other circumstances, more difficult to handle than did the others of the eight cited above, with whom the writer ultimately succeeded.

The figures given, namely, that, among sixty subjects, about fifty-two would be fit subjects for muscle-reading tests may be compared with estimates previously made. Gatchell speaks of 'good' subjects, without specification of the degree of effectiveness required to admit one to this rank, and cites as such, 'about one person in five among young people and one in ten or twenty among adults.' The present estimate of fit subjects would be about twenty-five in thirty. This does not mean, of course, that long and complicated experiments would succeed with such a large percentage but that the simple test of locating an article within the compass of a fairly large room would be easily achieved. Pfungst's tests in the laboratory gave complete failure to react with involuntary movements only in the case of two out of twenty-five subjects. Cumberland estimates that he would succeed with nine out of ten persons. Such reports agree well with that given here.

V.

To turn now to a discussion of the questions already formulated. First, as to the effect upon the outcome of the experiment of the subject's attitude toward it. Will scepticism as to the result, or hostility toward the operator's claims, or knowledge of the *modus operandi* result in the inhibition of the involuntary movements that otherwise might result from the situation.

Subjects grouped in respect to their attitude toward the test fall into three classes. There are, first, those subjects who are predisposed to believe in the operator's power 'to read their minds.' Such subjects are charmed when the operator succeeds with them, taking success as a compliment to their strength of will, their magnetic influence, or as evidence of the operator's occult powers. There are, secondly, the sceptical subjects who are inclined to believe that a trick explains any successes they have witnessed, who are angry and ashamed if they prove to be usable subjects. A third class of subjects apparently submits to

the test with little predisposition other than to follow the operator's directions with perfect candor.

An attempt to classify one's subjects with reference to their faith or scepticism is, however, obviously open to gross errors.[1] One can only conjecture a subject's attitude from his behavior; to resort to direct questioning is of little value. But the acceptance of success as evidence of some occult influence and an eagerness 'to have one's mind read' bear witness to a high degree of credulity. A sceptical attitude is much harder to discern, although it is sometimes evident from a subject's scornful exclamation, "You couldn't succeed with me!" Such a subject will not believe, except from first-hand experience, that the guidance in such tests is involuntary.

The notes of the writer show that success has often been achieved, and at times with great ease, when the subject's attitude was evidently one of profound scepticism as to the outcome. The chagrin of the guide at the success of the operator was frequently ludicrously apparent. On the other hand, failure occasionally resulted even with a highly suggestible guide, a fact not surprising of course since failure to concentrate attention might be cited as a cause. On the whole, however, the difficult subjects were those who assumed a critical attitude during the course of the experiment. It is customary to assume that the result of such scepticism is to fasten the reagent's attention on the idea of keeping the operator away from the chosen object. That such is frequently the case is shown by the fact that with some subjects it suffices to change failure into success by a shift in tactics, by following the line of most rather than that of least resistance. What is sometimes called 'physiological dishonesty' issues therefore in expression, however

[1] In a semi-public test at the University of Wyoming, the writer once attempted to effect a segregation of 'believers' and 'unbelievers' by asking spectators to seat themselves on the right if they thought they would be good subjects for muscle-reading; if not, to take seats on the left. The majority of those so instructed took seats on the right. Subsequently, however, the statement of the president of the university that he must sit with the 'unbelievers' induced all but a handful of those who were already seated on the right to move over to the left! With one exception, however, the 'unbelievers' who were tested proved as 'readable' as the 'believers.' The president was found to be an excellent subject.

difficult its interpretation, as evidently as does 'physiological candor.'

Pfungst[1] reports that involuntary movements are affected by faith. Even the most 'fit' of the operators with Hans, the horse, were unable to get answers from him when, according to their understanding of the situation, conditions had been so varied as to render success impossible. Pfungst also quotes from records relative to table-tipping and wand-divining to show that with the cessation of expectation of results none came. Pfungst explains this inhibition of expression as the result of diminished tension due to lack of faith in the outcome. Frequently, however, attention is actually concentrated upon something other than it was before. The involuntary expression of the thought, "The table won't tip" may be wholly different from that accompanying the thought, "The table is going to tip." Variation in muscular tension with variation in expectation must, however, be conceded.

Complete passivity in the face of actual concentration of attention is much less frequent than misleading tension; it is, in fact, of such rare occurrence that the writer is ready to assert such only in occasional tests with perhaps four or five subjects.[2] Of course, the absence of all muscular indications could, even in these cases, be charged to failure to concentrate sufficiently. The writer who belongs to this group of subjects and whose arm and hand during visual (though not verbal) concentration of attention may remain perfectly limp, is inclined to believe that muscle-reading actually reveals to some extent the facility with which nervous energy is drained to the motor regions of the cortex. The habitual absence of a high degree of expectation even when attention is concentrated would suggest several interesting questions as to the mental constitution of a person exhibiting such a tendency. Is it not possible that lack of readiness toward a motor discharge might lead to weak expectation as well as the reverse? If so, the relation of weak expectation to a critical or neutral attitude would demand attention. In any

[1] *Op. cit.*, p. 112 f.

[2] Such a statement must of course be taken with the understanding that the operator's skill in perceiving muscular changes was limited.

case, one needs to distinguish between the subject who, through disbelief in the operator's claims, attempts actually, though involuntarily, to thwart him, and the subject who submits to the test without expectation of any sort. The latter subject is the harder one to handle.

In an effort to note what effects would result if the subject were instructed to keep the reader from discovering the object selected, tests of this sort were tried with eight guides. It was found that if the guide tried to 'fool' the operator by actually concentrating on another object rather than the one selected, he could succeed easily. On the other hand, the attempt to keep the reader from success by making the mind a blank, by relaxation or stiffening of the muscles, or by such verbal inhibition as saying, "You can find it," was a failure. These experiments were few in number and, for the most part, tried only upon particularly 'fit' subjects. A series of experiments in which various methods of inhibition should be tried would be of value as a supplement to the tests to be reported later.

The degree to which expectation is excited by an anticipated end and the tension which accompanies such expectation is nicely determined in a series of tests in which expectation is unsatisfied, for the anticipated result fails to occur. A few of such tests were tried in connection with the present investigation. To bring about the desired conditions, it was necessary to blindfold the guide as well as the reader and to instruct a third person, in the absence of both, to remove the selected article after the subject had placed it in position or else to block the pathway to it. The results furnished pretty illustrations as to the motor outcome of baffled expectation. Frequently, under such conditions, the movements of exploration became extensive. Nor did the subject always confine himself to exploration of the immediate neighborhood; he sometimes rambled throughout the whole room. Other subjects in failing to realize their expectation indulged in suppressed or overt exclamations. A nervous fluttering of the hand, very difficult to describe, frequently was noticed. H, one of the most valuable subjects for this test because of the exceeding urgency of her expectation, reported that failure to realize her expectation —

which always takes the form of confirming her visual image of the object to be located — results in a complete blotting-out of the object from memory. With the annihilation of the object, the subject is 'lost,' a distressing experience, accompanied by bewilderment and faintness and comparable to the subject's experience of being lost in a hazel-copse as a child. On at least one occasion it resulted in a peculiar pain in the head. Meanwhile, the operator receives indications of the subject's state of mind through the wild fluttering of the exploring hand, a fluttering perfectly evident to the spectator as well as the operator but of which the subject (when questioned later) reported unawareness.

Pfungst[1] found that certain agents who worked with Hans succeeded in obtaining answers at their first trial, but not thereafter. He explains this result on the ground that attention was in the first trial at a higher tension than at any succeeding trial. On the other hand, too great concentration frequently led to premature relaxation of tension and resulted consequently in errors on the part of the reagent. On the whole, practice was needed in order to achieve the degree of tension required for successful operations. After practice less effort was required than at first. The present writer has noted similar facts, except that after one success with a given subject she has never found it difficult to achieve a second,[2] although in one case several failures intervened between the first and second success. Usually, the first success conciliates the subject; thereafter, success is more and more easily achieved. There was manifestly less effort on the part of the subject in the later tests; there was less tension evident but more initiative.

Pfungst found that 'Hans' was, as percipient, very little

[1] *Op. cit.*, p. 148.

[2] The difference between the muscle-reader and the percipient in Pfungst's experiments, whether Hans or a human reagent, should be noticed. The muscle-reader has the advantage, since by relaxation of the subject's muscles and by such feints as tentative moves — moves made suddenly and sometimes violently — he is able at times to surprise the guide into involuntary indications of the direction of attention. The operator who reacts to a visual perception of an involuntary movement enjoys no such opportunity. The compensating advantages are, of course, the greater precision and simplicity of the latter test.

affected by the presence of spectators, although his human partner in the test might be influenced by the social environment. In the present test the general effect of an audience may be summarized as follows. Frequently, the presence of spectators so embarrasses subjects as to render concentration of attention difficult. Just as frequently, however, the conditions increase expectation and magnify involuntary movements. The writer is as operator rendered somewhat 'nervous' and less sure of herself by an audience. Blindfolding reduces this timidity and a first success puts her at her ease. It is possible that a first success also influences the attitude of later subjects and renders success an easier matter. Moreover, spectators frequently contribute to success by their movements in watching the test, their variations in tension and relaxation made manifest by differences in breathing and the like. No tests, therefore, in which a control of conditions was desired, was tried in the presence of more than one spectator. When it was possible even this spectator was dismissed.

Other investigators, as Beard, have reported that a knowledge on the part of the guide of the *modus operandi* had an inhibitive effect. The writer never made any secret of the explanation of muscle-reading. Frequently, in fact, the explanation was given before the demonstration. It does not follow that the explanation was accepted. One of the surprises of the investigation has been the refusal of many subjects to accept the writer's explanation of her success. One guide (H) insists that she finds by actual experiment that when blindfolded she is unable to move as directly and accurately to the object as the reader does and that, therefore, the reader must be responsible for the guidance. What is emphasized by such facts is the extraordinary difficulty of bringing such involuntary movements to attention. Only a few of the subjects tested by the writer have ever succeeded in observing them even when warned to be on the watch. Certain subjects were, however, put on their guard by the explanation given them and it is unquestionable that in the case of these few knowledge of the explanation rendered success more difficult. When, however, success was achieved these subjects were of all the most mystified. The vital ques-

tion whether these involuntary movements are merely unobserved or actually unconscious is one which at this point the writer is not prepared to discuss.

VI.

The second division of the discussion involves a consideration of the degree of concentration needed for success. In the present investigation no measurement of this was possible. Pfungst's tests, in which a too intense concentration led to premature relaxation of tension with a resulting error, usually of minus one, in the calculation and an insufficient concentration led to an insufficient relaxation with an error of plus one or more in the calculation, show with great precision the degree of attention attained. Nothing of the sort was possible in the tests reported here except that the operator frequently observed relaxation which was premature and therefore incorrectly identified an object perhaps in the near neighborhood of the correct one.

The interest in the present investigation turned rather upon the effect upon involuntary movements of a shift in the method by which attention was controlled. The experiments had not gone far before the bearing upon success of the control utilized was perceived. Success was achieved with some subjects more easily with their eyes open than with their eyes closed. With others these conditions were reversed. Again, there was frequent report of a verbal control; the guide, for instance, said mentally, "It's the book over there on the radiator," or used similar descriptions. Now the verbal method seemed to Dy and Dw, both of whom concentrated on the object by focusing it visually or by forming a mental picture of it, a strained and artificial method of control. It therefore surprised them greatly to discover that a shift in their own control from visual to verbal assured success in their experiments upon one another, an issue which up to the time of the shift had been an uncertain and sporadic occurrence. It was also found that other difficult subjects became docile when asked to concentrate verbally. Moreover, in the case of effective subjects, whose control was visual, it was found that a shift from the visual to the verbal control

frequently resulted in more extensive movements and more pronounced initiative. Evidently the matter of verbal control deserved consideration.

Laurent[1] in the article previously quoted reports that the guide in the muscle-reading tests was asked to form a visual image of the object selected and also to think of the direction in which it was necessary to move in order to get it. A method of dichotomy was effective for the latter. The guide, that is, thought 'left' or 'right.' Laurent makes no comment upon the choice of verbal directions for the tests. In his experiments upon thought-reading without contact, subjects who resort to unconscious verbalization are of course necessary to the success of the experiment if Laurent's explanation of success as dependent upon hyperacousie on the part of the operator be accepted. The interest in such tests is, however, fundamentally different from that of the tests to be recorded in which the effect of mental verbalization upon involuntary movements read through contact is in question.

Pfungst[2] found that commands to 'Hans' spoken aloud were frequently more effective than commands merely represented mentally. This effectiveness was determined by the strong tendency on the part of the experimenter to accompany such spoken commands with involuntary movements, a stronger impulse to such expression being present under such circumstances than under the conditions of mere thought of the command. With practice, however, overt or suppressed articulation could be omitted for mental representation was sufficient to call out the involuntary movement. Again,[3] the observation was made that some experimenters, failing to obtain results on account of fatigue from previous tests, could again achieve success by a shift from abstract calculations to concrete representations. Pfungst's explanation of such facts is, I believe, based upon the greater concentration of attention effected by overt articulation of a command or by concrete perception of an object. Such observations, whatever their explanation, are akin to those that suggested the experiments now to be described.

[1] P. 484.
[2] *Op. cit.*, p. 72 f.
[3] *Op. cit.*, p. 108.

VII.

Before conducting a complete series of tests to determine the relation between different modes of control, a somewhat crude experiment on the efficiency of verbal control to induce involuntary movement was tried. Certain subjects, who had no knowledge of the purpose of the test, were asked, instead of placing an article, to memorize a sentence type-written on a slip of paper and to repeat over and over mentally, while in contact with the operator, the words so memorized. The sentences were so worded as to rule out if possible visual imagery and were purposely rendered as schematic as possible so as to isolate the verbal element. In order that when Dy served as reader she might not be aware of the reading of the slip memorized, seventeen of these slips were prepared some time before the experiment was to be tried and the guide on the occasion of the test drew at random one of them from the bundle. Two tests, under these conditions, are quoted in full. In both of these tests the same slip was drawn which read as follows: "Object is eighteen inches above and six inches to the right of the lower part of second obstruction which is two feet east of first obstruction which is three feet south and fifteen feet north of entrance." The subject made, usually, no attempt to translate such instructions into terms of the surroundings in which the test was tried. No suggestion was made that close adherence to the directions would issue in finding a pin which was stuck into the under side of a book-shelf. Both the operator and guide were blindfolded before contact was established. The notes taken at time of the tests follow.

"Mar. 4, 4 P. M. Reader, Dw. Guide, W. W memorized slip 8. First trial, much initiative, but failure to discover object. Dw went around the room, south, then east, then north, then west, returning to starting point. Tendency noticed for W to swing around Dw. Second trial. Care was taken that W should be placed, by the spectator (the writer) facing the wall so that directions if followed would result in success. This precaution had been overlooked in the first trial. At start, tendency for W to swing around Dw again noticed. Then success in locating article in 90 s. Dw however approached the object

from the left instead of the right; W's memory of the slip was found to be faulty in this respect. W reported that he had no visual consciousness during the test; he repeated the words of the slip over and over. His surprise at there being any outcome to the experiment was great."

"May 7, 3 P. M. Reader, Dy. Guide, M. M memorized slip 8. Thinking the test was to be one of distraction and that the words memorized, which she supposed were meaningless, were to be repeated over and over so as to distract attention from the actual object, M hid an object on the ledge in the southeast corner of the inner room. This object was completely blotted out by the repetition of the memorized words. There was much initiative on M's part, as the slip directed. Success in 80 s." The chart, kept by a third person, on which the course taken was mapped out shows a certain amount of circling movement before the article was located.

Both W and M are exceeding automatic in their movements; both show a strong tendency to use verbal imagery which issues at times of difficulty in actual articulation. Other subjects gave different results. H, for instance, immediately translated the words read into visual terms, and remembered them in such terms. She also visualized an object which should be found as an outcome of the test. Such an object was specifically defined as, for instance, "a small black ball about the size of a cherry on a white string that is suspended from a nail above the blackboard." Failing to realize such an expectation, H becomes confused and distressed.

VIII.

The general outcome of the tests showed, however, the potency of verbal imagery in the initiation of involuntary movement even when the words ideated are felt to have little meaning. But further questions arose. For example, would verbalization of the name of the object avail as did verbalization of the direction in which the movement should be made? It seemed, in fact, probable that the potency of the verbal method was due to the enforcement in this manner of attention upon the pathway and that any other method that threw attention upon the pathway as definitely would be as effective.

Throughout the tests, it must be remembered, success is due to the involuntary indication of the path to be followed in going to the object. If this path be indicated, further consciousness of the object is immaterial.

To determine, however, the motor effectiveness, involuntary indication of the path to be followed, of various possible controls, the eight following possibilities were selected for experiment. The guide was required, that is, to concentrate by instruction upon some particular element in the situation. (1) The guide focused his eyes on the chosen object; (2) the guide focused his eyes on the pathway, step by step; (3) with eyes open and roving, the guide 'verbalized' mentally the name of the selected object; (4) with eyes open and roving, the guide 'verbalized' mentally the direction in which the reader should move in order to reach the object; (5) with eyes closed, the guide visualized the object; (6) with eyes closed, the guide visualized the pathway; (7) with eyes closed, the guide mentally 'verbalized' the name of the object; (8) with eyes closed, the guide mentally 'verbalized' the direction in which the reader should move in order to reach the object.

These particular methods were selected so as to determine, if possible, the relative value in the induction of involuntary movements of open versus closed eyes, concentration on the pathway versus concentration on the object, concentration by visual control versus concentration by verbal means. One series of tests consisting of eight separate tests, one test each under the different conditions suggested, would give four tests each with closed and open eyes, with concentration on pathway and on object, with concentration by visual and by verbal means. In the earlier experiments the method of 'control' was suggested to the guide and the pathway traversed in finding the article was carefully mapped; the time taken for the location of the article was also recorded. A comparison was then instituted relative to the precision and rapidity of movement under the several conditions of concentration.

Later, the experiment was rendered more definite by the adoption of the two following methods, the second of which proved the better and was finally used without recourse to the

other. The first method attempted to determine the value of a particular method of concentration by measuring the distance traversed by the reader during a given time; the second method sought to measure the relative efficiency of the different methods of concentration by recording the time that it took for the reader to traverse a given distance.

The first method may be described in detail as follows: The guide first chalked on the floor an irregular pathway, indicating by cross-lines each meter-distance. The guide also prepared a list of the eight methods to be used in concentration on the object and then selected and indicated by number the order in which he intended to use these methods. The reader blindfolded was led to the beginning of the chalked path, contact was established and a third person gave to the guide the signal to begin concentration by gently touching him on the arm by means of a long pointer, at the same time starting a stop-watch. At the end of every twenty seconds, when the guide was signaled to in similar fashion, he changed his method of concentration. During the intervals the third person charted carefully on a map that had previously been drawn to scale to correspond to the chalked pathway, the pathway the reader followed. Thus every deviation from the correct pathway, or, if none, the exact space traversed in any given twenty seconds could be determined. The value of this method lay in its throwing into sharp relief the variations in muscular tension effected by a shift in mental control.

In the second method, simple irregular pathways, always three meters in length but varying in form, were chalked by the guide and the time needed for the reader to traverse these pathways under the conditions of the several tests was recorded by the use of a stop-watch. In these tests the object was in every case the same, namely, a piece of chalk placed on a chair at the end of the pathway. The short pathway and the easily identified object were purposely chosen in order to shorten the time needed for controlled concentration and to simplify the identification of the object. As before, the reader was blindfolded and then led to the beginning of the pathway.

It was essential throughout that the reader be in complete

ignorance of the particular method of concentration used in a specific test and that she refrain from making tentative moves, waiting passively in each case to receive the initiative from the guide. It was also desirable that the guide have no idea of the particular purpose of the test, for suggestion as to the results anticipated would no doubt affect the outcome. In the case of Dw and Dy as guides this last condition could not be fulfilled. As, however, the course of the previous experiments had unexpectedly revealed the varying effectiveness of different methods of concentration, these tests served to put into more precise form conclusions that had already been reached in the course of the preliminary experiments.

In general, the following sources of error were present. On the part of the guide, failure to control attention in the way desired on account of lack of practice or, at times, on account of fatigue; on the part of the reader, variations in skill due to fatigue or anticipation. Moreover, the reader's observation of muscular conditions was defective since any attempt to throw attention upon such during the course of the experiment was apt to interfere with the passivity so essential to success. With increasing practice, such observations interfered less and less with skillful reading. The reader, as was said above, refrained from tentative moves; to assert absolute absence of initiative would, however, be impossible.

An important preliminary test was that tried in order to ascertain the method used naturally by the guide when asked to concentrate on an object. By reference to this test it was attempted to determine whether or not the natural method of control were the most effective one from the reader's standpoint. After practice with any particular subject, the reader found it possible to name with considerable accuracy the method of concentration that the subject was using in a particular test. The constancy with which variations in muscular tension ensued upon changed conditions was surprising, although such changes became less noticeable after the series of tests had been repeated many times, with a given subject.

IX.

In discussing results, the tests upon Dy and Dw will be first considered. Each it will be recalled served as reader or guide for the other. Both were difficult subjects to handle. Although verbalization occurred at times, both concentrated on the object, for the most part, visually. With Dw serving as guide there was considerable initiative, apparently in the direction of the eye-movements. The reader frequently went directly toward the chosen object at the beginning of the test; then withdrew and rambled aimlessly, although apparently in obedience to Dw's initiative. Identification of the object was exceedingly difficult, even when it was touched. Both premature and insufficient relaxation were noticed. When Dy attempted to read slowly instead of rapidly and rendered herself unusually passive, waiting in every instance for the motor impulse to begin with the head, success was more apt to be achieved. If Dy attempted tentative movements, Dw responded with the suggested movement. Dy, on the contrary, was as guide absolutely passive; her hand hung limp. Dw reported that it was necessary to pull her forcibly if movement were to be initiated at all. It should, however, be stated that frequently Dy and Dw would each insist that in a particular instance the other had taken the initiative. With Dy as guide, distraction of attention rendered success more likely to occur. This result did not occur in the case of Dw. In the earlier experiments, up to May 15, before, that is, any attempt was made to control the method of concentration, Dw as reader worked with Dy as guide some fifteen different times. In five of these tests Dy's attention was distracted from the object by counting aloud. In the ten experiments without distraction, success or partial success occurred four times; in the five tests with distraction, three times; seven successes in all. With Dy as reader and Dw as guide, seventeen tests were tried; twelve without and five with distraction. Seven successes or partial successes occurred when there was no distraction; one, when there was distraction; eight successes in all. By a partial success is meant the approach towards and perhaps selection of the chosen article without confident identification of it.

The notes on the tests tried May 15 include the following statement: "Today's success may be due to the guide's method of concentration of attention on the object or may be due to the reader's unfatigued condition." In any case, on that day, for the first time, attention was controlled according to instruction, the 'controls' suggested including one in which verbal suggestions were mentally given as to the proper direction of movement. This 'control' resulted, both when the eyes were open and when they were closed, in rapid and easy success. On this occasion, Dy served as reader and Dw as guide. May 20, the rôles were reversed and again the mental giving of verbal directions proved successful, although success was more slowly achieved than on the previous occasion. The deliberate attempt to control attention, whatever the method used, probably resulted, on the whole, in actual increase of attention to the object with less consciousness of inhibition of the guide's movements. The tests that followed introduced systematic control of attention and attempted to determine the value of each different 'control' by a determination of the extent of movement during a given interval, the course followed by the reader being mapped out carefully as described in the first method.

Although there was considerable variation in detail, it became evident from eight series of tests in which Dy served as

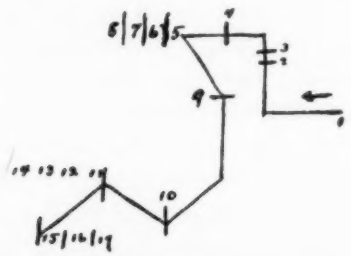


FIG. 1. 1, 9, eyes open, 'verbalized' pathway; 2, 10, eyes closed, visualized pathway; 3, 11, eyes open, fixated pathway; 4, 12, eyes open, fixated object; 5, 13, eyes closed, visualized object; 6, 14, eyes open, 'verbalized' object; 7, 15, eyes closed, 'verbalized' object; 8, 16, eyes closed, 'verbalized' pathway.

guide, that concentration on the path induced much more movement than did concentration on the object. Moreover, a verbal concentration on the path was a more reliable method than was

control by visual means. Verbal concentration on the object had little effect. Holding a visual image for any length of time requires great effort on Dy's part, although chalking the pathway lessens the effort required to visualize the path. Fig. 1 reproduces the chalked pathway used in the test of July 15. The diagram is drawn to scale, a centimeter for a meter. The cross-lines indicate the places at which the control of attention was shifted, such a shift occurring every twenty seconds. The numbers on the figure indicate the sort of 'control' utilized by the guide as interpreted in the legend below the figure. The distance moved by the reader during any particular twenty-second interval can be determined by the distance between any two cross-lines; the method used by the guide in concentrating attention can be seen by reference to legend. Where numbers or cross-lines appear to fall off the path, hesitation (without advance) is indicated. In this test the reader never left the pathway, although during several intervals there was no apparent progress.

Dw when serving as guide gave somewhat different and, on the whole, less constant results. As suggested before, Dw's attention is apt to be diverted by visual stimuli when her eyes are open. This observation accords with the fact that in the tests now being described concentration on the path, by whatever means, issued in success if the eyes were closed. Thus verbal concentration with the eyes closed proved more effective than the same method of control when the eyes were open. Visualizing the pathway, with closed eyes, was also an effective method of control.

At this point in the experiment the method was shifted to that described as the second method (see section VIII.). The value of each method of concentration was now estimated by the time taken by the reader in traversing a three-meter pathway. The results of this test confirmed those obtained in the preceding test, so far as Dy was concerned. The results from Dw were ambiguous and unfortunately circumstances made it necessary to bring the investigation on this guide to a premature close. The full notes on a test with Dy are given; Dw served as reader.

"Dy when serving as guide notices a strong tendency to close the eyes when focusing the eyes on the object or on the pathway. This tendency is perhaps due to the fact that meaning evaporates from a visual perception after a few seconds steady concentration upon it. On the other hand, distinct visualization (mental) affords intense concentration for a few seconds, after which the visual image fades completely and there is a strong desire to open the eyes and get a new picture. While controlling attention by the use of mental verbalization, there is little need of inhibiting visual control. During visual concentration, all sort of irrelevant verbalization occurs. Strangely, Dy serving as operator notices no such tendency to verbalization; at frequent intervals, a stray visual image of the pathway or of surroundings enters consciousness. The specific tests resulted as follows:

"1. Dy gave, mentally, with eyes roving, verbal directions to Dw. Dy said, 'To right'; then 'Towards telephone'; then, 'Straight ahead.' Strong tendency noticed to look in direction named. Dy deliberately kept eyes from direction named. After words were once determined upon, Dy could repeat them mechanically. Success, 72 seconds.

"2. Dy closed eyes and formed a mental image of the object (a piece of chalk). Muscles were very tense. The reader got off the path, but brushed terminal chair, which caused chalk to rattle. This shortened discovery. Dy took no initiative. There was long hesitation before the reader moved. After the first seconds Dy found visualization very difficult. She opened her eyes occasionally to get a new picture of the chalk. There was also some difficulty experienced in ruling out the visual picture of the chalked pathway. Strong tendency to turn head and closed eyes toward object. When they were deliberately turned aside there was great tension in the neck-muscles. Dy found herself saying mentally, 'I can see it! I can see it!' Success, 126 seconds.

"3. Dy visualized the pathway, which, to assist the process, had been chalked in the form of an equilateral triangle. Muscles were reported to be less tense than in the preceding experiment. Dy found no difficulty in shutting out an image of the object.

There was a good mental picture of the triangle, but suddenly the triangle shifted its position in the room, which induced confusion. Dy was obliged to open her eyes and fixate the triangle again in order to get it in proper position. She verbalized involuntarily, 'I've got the triangle!' and as Dw advanced, 'That's right!' Success, 67 seconds. Test to be tried again.

"4. Dy repeated over and over again with eyes closed, the word 'Chalk,' actually innervating tongue and lips. There was no overt articulation. The verbalization was largely automatic; there was no meaning to it; the object was forgotten; attention was actually on the movements of the jaw. Once, there was a flash in Dy's consciousness of a picture of the pathway, accompanied by a picture of the whole floor of the laboratory. Once, the piece of chalk was seen mentally. Dw reported that the muscles of the wrist were tenser in the earlier than in the later part of the test. Pathway was not followed accurately. Success, 102 seconds.

"5. Dy watched the pathway step by step. Dw followed the pathway accurately. Dy found it hard to inhibit verbalization of thoughts on a topic foreign to the experiment. Unless Dw moved so as to change the point of visual fixation, the whole process lost meaning for Dy. Success, 133 seconds.

"6. Dy focused her eyes on the object. It was 40 seconds before the first movement was made. Dy verbalized mentally, 'It's no trouble to look at it!' Then her attention wandered and the object became unmeaning. Dy said mentally 'Dw should be blindfolded; it would be easy for her to open her eyes,' then, as Dw left the pathway, 'I must remember to enter in the notes that she got off the path and rambled.' At last, Dy feared failure; she said mentally, 'I must concentrate!' With great effort she inhibited verbalization. Success, 245 seconds.

"7. Test 3 was repeated (visualization of pathway). Good control; visualization excellent; verbalization inhibited most of the time, although once Dy said, 'I mustn't open my eyes!' and again, 'If I don't talk to myself, I won't have to write such a long report.' Pathway was followed pretty accurately. Success, 148 seconds.

"8. With eyes closed, Dy told the reader, mentally, in what

direction she should move. She said 'Straight ahead; straight ahead.' Muscles were relaxed. There was no visual imagery; no effort. Success, 60 seconds.

"9. With eyes roving, Dy 'verbalized' mentally the word 'chalk'! It was ninety seconds before Dw moved. Dw then rambled over a big part of the room. The locating of the chair was perhaps accidental. Success, 235 seconds.

Arranging the tests in the order of time required for location of the object and beginning with the test requiring the least time, we get the following arrangement: (1) Eyes closed, verbalization of direction of movement, 60 s.; (2) eyes open, verbalization of direction of movement, 72 s.; (3) eyes closed, verbalization of the name of the object, 102 s.; (4) eyes closed, visualization of the object, 126 s.; (5) eyes opened, focused on the pathway, 133 s.; (6) eyes closed, visualization of the pathway, 138 s.; (7) eyes open, verbalization of the name of the object, 235 s.; (8) eyes open, focused on object, 245 s. It was unfortunate that the series could not be repeated many times as was done in the case of other guides. Dw's help was needed as reader and, as was stated above, circumstances prohibited Dw's further assistance.

How very slowly the reading went when Dy served as guide may be realized by a comparison of the time-reading in her case and in the case of H, whose record remains to be discussed. In H's case, the maximum time-reading in nine complete series of eight tests each, was 25 s.; the minimum time-requirement was 4.5 s.

X.

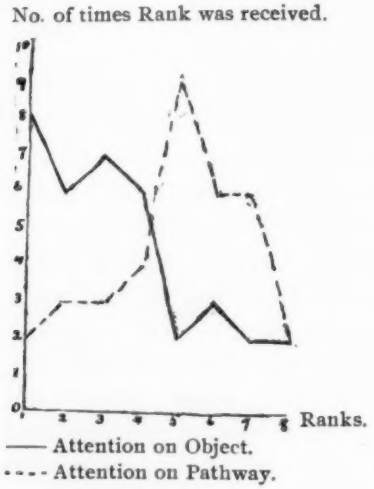
H, as a guide in the test, affords, in almost every respect, a complete contrast to Dy. H has served so frequently as a subject for the writer that before beginning the series on muscle-reading, the writer was aware of many of the features of her mental make-up. She knew, for instance, that H gives evidence of automatic tendencies; that, for H, to think and to act are almost synchronous; that long mental hesitation is for H distasteful. H's mental stuff is visual to a higher degree perhaps than that of any other person the writer has ever tested. It is not only visual but concretely visual and circumstantial to the last detail.

In anticipating a committee meeting, for instance, H sees each individual member of the committee in the proper environment. The mental picture includes the least details, even to the shoestrings that lace A's and B's shoes. Moreover, in her visualization, H never departs from the dictates of experience. A description of a bird occurs in her reading; immediately, she illustrates the text with a mental photograph of a little gray bird that she saw, a year ago, sitting on the lower branch of the cottonwood tree that stands at the corner of M and N streets. Proof-reading with the writer one day, H stumbled over the accent of the word 'automatic.' Finally she remarked, "I've got it now. I've put a little picture of Tom H. over the letters 'tom.'"

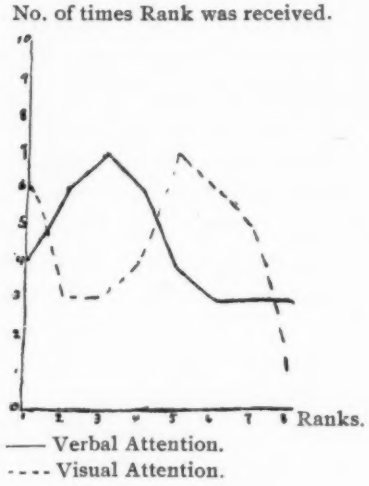
H was a most effective subject in the present tests. The results she gave were constant; her introspections were of high value. Her only difficulty lay in the inhibition of visual control when it was desired to isolate verbal control. To do this completely is painful; as said before, H under such conditions feels 'lost.'

The writer has record, with full notes, of some ninety muscle-reading tests carried on, by Dy, with H as subject. From nine series of three-meter tests (eight tests in each series, eight different 'controls' being used as described in section VIII.), the following curves were prepared. The value of each 'control' in its own series was determined by the length of time taken to traverse the three-meter path, previously chalked. Each test was given a rank in its own series, the possible ranks numbering from one to eight. When two tests took the same time, they were given the same rank. From the seventy-two tests the following curves were obtained. The horizontal numerals represent the possible ranks in the series; the vertical numerals represent the actual number of times each rank was received by the control in question. Six curves were plotted: the first (Curve I.) shows the comparative effectiveness of 'control' when attention is on the pathway and when it is on the object; the second (Curve II.) shows the comparative effectiveness of visual and verbal 'control'; the third (Curve III.) shows the comparative effectiveness of the 'control' with the eyes open and with the eyes closed.

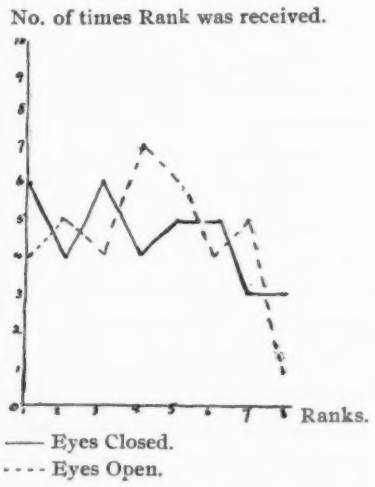
From these curves it is evident that success was achieved in shorter time when the object was focused and the attention with-



Curve I. Subject H.



Curve II. Subject H.



Curve III. Subject H.

drawn from the pathway. Mental verbal control, on the whole, induced slightly more rapid movement than did visual control. It made very little difference in rapidity of the test whether the

eyes were open or were closed, although, if the results permit generalization, the 'control' was slightly more effective when the eyes were closed. Adding together the ranks received in the nine series by the different 'controls,' the lower numeral indicating the more rapid initiative, results as follows: Attention on the subject, 123; attention on the pathway, 176; verbal attention, 144; visual attention, 155; 'control' with eyes closed, 148; 'control' with eyes open, 151. If one sums the ranks in the nine series for each of the eight 'controls, the following ranking occurs: Eyes closed, visual image of object at focus of attention, 27; eyes closed, attention on verbal naming of object, 31; eyes opened, focused on object, 31; eyes open and roving, attention on mental 'verbalization' of name of object, 34; eyes closed, attention on 'verbalization' of direction of movement 38; eyes open, attention on 'verbalization' of direction of movement, 41; eyes open, visual focusing of pathway, step by step, 45; eyes closed, visualization of pathway, step by step, 52. In time, the tests took from 4.5 seconds to 25 seconds. In 65 per cent. of the seventy-two tests, the time-reading is below 8 seconds.

Following the pathway is such an automatic process for H that any attempt to focus it voluntarily involves effort of attention. The notes show that when attention was thrown upon the pathway, the muscles of the wrist and arm stiffened, the initiative was very slow and very precise, and there was every indication of effort. Although H very rarely succeeded in wholly ruling out visual imagery — a mental picture of the chalked path in whole or part was usually present more or less clearly — any attempt to throw visual imagery into the foreground resulted in increased tension. A visual concentration on the pathway led to the most accurate and precise tracing of the pathway. Concentration on the object reduced the muscular tension and quickened the process of reading. Mental naming of the object proved very effective. When allowed to select her own method of 'control,' H resorted naturally to visual concentration on the object, which, as the results of the tests show, was a very effective method.

H's guidance in muscle-reading is pronounced. Frequently

all that is necessary is to place one's self in advance of H, establish contact (although contact is often unnecessary, probably), and then to move forward with her. Verbal control, especially, issues in extensive movements on the part of the whole body; there is a very free swinging movement on the part of the arms. The change to the muscular tension that accompanied a visual focusing of the pathway and the insistence upon the precise tracing of this pathway was very noticeable. Of her initiative, H is unaware, and as stated before, argues that the reader must be responsible for the direct location of the object since she herself finds it impossible, when *blindfolded*, to locate it voluntarily as accurately and directly as the reader does in the test. This statement led to trial of the time that it took H voluntarily to pace a three-meter path, similar to those used in the tests. The time-readings ran from 4 seconds to 8.5 seconds, with this curious result that, with her eyes closed, H actually did find it difficult to move directly to the terminal chair. If she actually ruled out of consciousness a picture of the chalked pathway, there was much facial contortion and an incoördination of movement that contrasted strangely with the quickness and precision of the involuntary movements.

XI.

Besides the tests on H, the three-meter tests were repeated on J, C and R.

J was, like H, a good subject for muscle-reading. The time-readings in eight series of tests (eight tests to a series) ran from 4 seconds to 36.2 seconds, with 68 per cent. of the time-readings below 8 seconds. It was found with J, as with H, that concentration on the object gave a shorter time-reading than did concentration on the pathway. The curves plotted to show the comparative effectiveness of such 'controls' in the case of J closely resemble those found for H. Voluntary concentration of attention upon the pathway resulted as in the former case in effort, greater muscular tension, and slower initiative. In J's case, however, and this in contrast to that of H, a verbal 'control' induced quicker initiative than did a visual 'control.' Naming the object mentally was by far the most effective

method for J. Visualizing at first required distinct effort, although during the course of the experiments this effort lessened and the muscular tension under such conditions became less noticeable. Closing the eyes raised the time-readings over those found when the eyes were open. When uninstructed, J uses verbal imagery of some sort.

The results with C were less well defined than those obtained with J and H. The time-readings ran from 7.4 seconds to 215 seconds, with 50 per cent. of the readings below 20 seconds. C showed a strong tendency to move in the direction of his eye-movements. Visual fixation of the object resulted in cutting of the pathway. When the eyes were roving, this tendency led to rambling, particularly if attention was maintained by verbalization of the name of the object. The closing of C's eyes made identification of the object a difficult matter for the operator. In general, success was more rapidly achieved when the object, rather than the path, was fixated, and much more rapidly achieved with a visual than with a verbal 'control.' Closing the eyes and giving verbal directions retarded the movement but issued in a precise retracing of the pathway. Focusing the eyes on the object proved to be the quickest method.

R (two series, of eight tests each) gave results very similar to those found with Dy. R was an exceedingly difficult subject to handle. Concentration on the pathway, particularly by verbal means resulted in success, although the reading was a severe drain upon the operator's attention. Visual fixation of the pathway also permitted success, so also, on one occasion, did a visual fixation of the object. Mental visualization on R's part resulted in failure on the part of the operator. As a matter of fact, R reports that he cannot be said actually to visualize at all. He knows how an object looks but cannot see it mentally. The time-readings ran from 11.4 seconds (verbal concentration on the direction of movement) to 223 seconds (visual fixation of the path). It should perhaps be noted that in the first few experiments, R gave evidence of much more involuntary movement than he did afterwards. He became conscious of his initiative and thereafter inhibited it deliberately. Dy's success under such conditions surprised him greatly. R showed

a strong tendency to lead to the chair and object of the test just preceding the one actually in progress.

XII.

Besides these tests on the subjects named, Dy tried one series each on nine other subjects. It was hoped to determine in this way whether or not any general tendencies were to be observed. One series each was probably insufficient for the purpose. The fourteen subjects taken together show that in the first test at least concentration on the pathway was on the whole very much more effective than concentration on the object; concentration by verbal means slightly more effective than concentration by visual means; and concentration with closed eyes more effective than concentration with the eyes open.

The individual, and not the group, results are of the greater interest. In a few cases, verbal concentration alone induced involuntary movements. Frequently, even with subjects in whom visual 'control' issued in involuntary motor impulsion, the verbal concentration induced freer and, apparently, more automatic movements. With one guide this shift from precise to free rambling movements occurred with the change from concentration with eyes closed to concentration with eyes open. With his eyes open, this guide (T) moved in a free rambling way toward the object upon which his eyes fell, the direction of movement shifting frequently.

The results obtained in the series of experiments under consideration may be summarized as follows. *Those guides in whom the motor impulse is strong, under all conditions, indicate the direction of attention by motor initiative. This initiative is, however, retarded, although frequently rendered more precise, by concentration on the pathway, that is, on the direction of movement.*

Those guides in whom the motor impulse is less insistent, if the experiment be a long one, frequently find their attention weakened by the conditions of the test. If, however, attention be thrown on the pathway (direction of movement), the motor impulse is increased, and attention is maintained by the shift of the point of fixation.

Verbal control produces, in general, a freer and usually less accurate initiative than does a visual control. The actual innervation of the vocal musculature may possibly have general motor accompaniments. Verbal control frequently rendered success possible with subjects otherwise refractory. Verbalization merely of the name of the object selected occasionally caused extensive rambling, at times in the direction of the eye-movements; for others, it induced a cutting of the pathway.

In the case of certain subjects, who moved in the direction of eye-fixation and that too without conscious direction of attention toward any particular object in the field of vision, blindfolding was contributory to success.

XIII.

The third question phrased for discussion related to the automatic tendencies revealed in muscle-reading with reference to Beard's and Laurent's observation that the guide's obsession by the suggested idea not only induces very extensive and free movements but also increases the probability of automatic activities of various sorts. The present tests gave frequent evidence of such automatism; the freedom and extent of the guide's initiative were, moreover, very surprising under such conditions.

The peculiar automatic tendencies observed in connection with muscle-reading have been rehearsed by the writer in another article.[1] To list them briefly, they include success in the location of an object although the attention of the guide is distracted from the object; recapitulation of the pathway followed by the guide in hiding or selecting the object of the test; a return to the chosen article of a preceding test, or to one thought-of as a possible object for the present test; an early indication of the level at which the article is actually hidden. The three-meter tests revealed a tendency on the part of the guide to return to the beginning of the chalked pathway if the operator went 'astray,' with, as before, a tendency to locate the chair and object of the preceding test rather than the object of the present test.

[1] 'Automatic Phenomena of Muscle-Reading,' *Jour. of Phil., Psychol. and Scientific Methods*, Vol. V., p. 650.

Such occurrences as those mentioned in the preceding paragraph could be artificially induced by the experimenter. The suggestion of a spectator that an object selected and placed in position by the guide should be rejected for another chosen by the spectator often induced a location of both articles. An experiment, called for brevity the 'either-or' test was also interesting in its outcome, although this varied with the individual tested. In this experiment, a third person selected and hid the object, stating to the guide, who was blindfolded, that it had been placed 'either' in one described locality 'or' in a second. To cite a particular case. J was told that the object had been placed 'either' on a high cabinet at the west side of the inner room 'or' on a low table at the north end. J decided to concentrate on the low table north and guided the operator thither, but all the movements of exploration were high up at a level with the cabinet. For a more detailed description of the conditions under which similar automatic activities occurred, the reader is referred to the article cited above.

The point of interest is the possible revelation of the 'mental set' even when attention is not concentrated rigorously or is concentrated upon something other than is revealed by the involuntary movements. Success in locating an object with the guide's attention distracted from it and the tendency to reveal involuntarily the location of an object previously thought-of, although at the moment of the test the guide's attention is concentrated upon something else are interesting features of the experiment. The persistence of an idea even after it has been dismissed from the field of attention is cited by Pfungst[1] as a source of error in his experiments. In his numerical tests such persistence of an idea, called by him after Müller and Pilzecker, 'die Perseverationstendenz,' resulted in the operator tapping a number corresponding to one previously thought-of rather than the number thought-of at the moment of test. The point here to be emphasized is that in such an instance, at least, the concentration of attention upon the desired idea is less effectual in the induction of involuntary movements, than is the subconscious or co-conscious second idea.

[1] *Op. cit.*, p. 106 f.

The results obtained in the three-meter tests, in which attention was voluntarily controlled, were similar in a way to the observation of the great effectiveness of subconscious ideas in revealing the direction of attention. The fact that the most impulsive subjects gave freer initiative than usual when attention was withdrawn from the pathway, although following this pathway accurately, is a case in point. The difference in muscular tension accompanying a labored concentration and an automatic initiative is perfectly evident to the operator. As has been stated, the latter was frequently able to tell the subject at the close of a test, the method utilized in the concentration of attention.

It is evident then that the most 'fit' subjects for muscle-reading tests will frequently exhibit automatic activities. Success will also be possible with subjects who are able to hold their attention steadily to a desired object. For brilliant success a certain amount of automatism on the part of the guide is required.

Laurent's [1] experiments upon muscle-reading without contact emphasized the fact that those subjects who were most obsessed by the suggested idea resorted unconsciously to suppressed articulation and that the operator, if also automatic in his tendencies, was brought by the test into an abnormally passive state of mind in which he heard unconsciously the verbalization of the guide.

In the present test the writer was on the outlook for any cases of pronounced verbal automatism. One or two striking instances of it occurred. Thus W when baffled would speak aloud and report, when questioned, that he was unaware of having said anything. The movements of M's lips became noticeable whenever she became absorbed in an experiment. H, when voluntarily controlling attention by mental verbalization, actually whispered at times to herself. So far, however, as she is aware, Dy was in no case guided by audition. In the two or three cases where she heard the suppressed whispering she misunderstood the words; in none of these cases did she permit such direction to supersede guidance by touch. Operating without contact, Dy is still dependent upon her perception

[1] *Loc. cit.*, p. 489 f.

of variation in the guide's movements; at most, she guides herself auditorially by noting variations in breathing and footstep. Very little attention, on the whole, was given, in the present investigation, to the auditory factor.

XIV.

The main interest in the present investigation was, as stated in the early part of the paper, to discover if possible a method of studying mental types. This purpose has been in part achieved, although a more rigid control of conditions would have been desirable.

Apart from limitations of this sort, the acquaintance that the muscle-reader gets with the expressive side of mental situations and with the individual variations in such expression is most striking.

First of all, the varying impulsiveness of subjects is noticeable. The extent of this variation was, as the foregoing report shows, very great. One would wish to determine the bearing of such varying impulsiveness upon the whole character of the subject. The writer's general knowledge of the subjects of her muscle-reading tests has led her to expect that the 'fit' subjects for the test will, on the whole, be those who in daily life exhibit few inhibitions either in judgment or action, who are hopeful and confident in their attitude toward things. The opposing type includes those more hesitant in act and judgment, more critical and reserved. How far the temperament is an expression of variation in the readiness of the motor discharge is a question worth detailed consideration. How far also the nervous energy released by concentration of attention is drained otherwise than through involuntary movements is of interest. No doubt this draining may take place in various ways, with consequent effect upon temperament.[1]

Eight subjects of the muscle-reading tests were also tested in their ability to maintain writing under distracted attention.[2]

[1] Manouvrier, L., 'Mouvements divers et sueur palmaire consécutifs à des images mentales,' *Revue philosophique*, 1886, 22, p. 204 ff.

[2] Downey, J. E., 'Control Processes in Modified Hand-Writing,' Part II., Monograph Supplement, PSYCHOL. REV., Vol. IX., No. 37.

The writing of the impulsive subject, under distraction, issued in a large free hand with frequent unawareness of the writing and repetitionary or persistence lapses. For the more self-controlled subject, writing under such conditions issued in writing small and labored, controlled consciously and with effort.

Varying impulsiveness was not, however, the only individual difference thrown into relief by the tests under consideration. Variations in the conditions under which the muscle-reading took place could be introduced almost without end and every such variation showed further possibilities as to the revelation of character by such means. Volitional tendencies so-called came out distinctly in the tests in which the subject found himself, unexpectedly, baffled. This baffling was effected by removing the object after the guide had placed it in position or by blocking the pathway by which the subject supposed it could be reached. Certain subjects were resolute and unfaltering in their insistence that the operator surmount any obstacle in her path; others, after a moment's hesitation, tried another way round, still others gave up at the first hint of a difficulty. The momentary 'pause' with which certain subjects reacted to the difficulty before initiating other movement contrasted strangely with the 'wild' explorations of others. The movements, it should be understood, were usually involuntary variations in muscular tension, not overt movements.

The 'either-or' test described a few pages back introduced an instructive variation in the conditions. The vacillation of attention with which certain guides met the situation threw into relief the quick decision of others.

It is difficult to comprehend without first-hand experience the wonderful accuracy of the operator's response to the slightest variation in the guide's muscular tension. H, for instance, has as guide placed a clock on a ledge above a long table which is three and a half feet wide and flat against the wall. On Dy's arrival at the table, H begins to chuckle mentally, thinking, "She can never reach it!" Dy raises herself on tiptoe and leans over the table, exclaiming "I can never reach it!" H sees in a visual flash Dy climbing the table and Dy actually pulls herself over the table and gets the clock. Such delicacy

in reaction gives the operator a unique acquaintance with the guide's mental processes, his uncertainty, his timidity, the course of his deliberations. The awkwardness of one of the writer's friends was thus realized in a new and unexpected manner when with this friend serving as her guide, she felt herself 'backing-up' to the object in a most ludicrous manner.

Muscle-reading affords a new method for investigating certain features of bodily orientation. The blindfolding of guides issued in instructive results. Not merely the timidity of some, under such limitations, and the confident orientation of others was noticed but also certain peculiarities of adjustment. A tendency on the part of the operator to indicate a position symmetrically homologous to that actually thought of by the guide was noticed by Romanes in the early English investigation and has also been recorded once or twice in the present investigation. Whirling a subject around several times rapidly after he has been blindfolded and before the test is on serves to complicate the latter peculiarly. Turning the guide adrift blindfolded in an unfamiliar room in which the object to be located has been placed for him by a third person and the place of location carefully described is an interesting test especially if the guide be a very impulsive one. The notes the writer has collected on this topic she is reserving for fuller treatment at some later time.

One of the most interesting traits that the muscle-reading tests revealed was the tendency to revert automatically to a past condition. This tendency described a few pages back has been extensively treated by Müller and Pilzecker [1] in connection with their experiments on memory. The persistence in the present tests was a motor rather than a sensory persistence. The authors mentioned above dilate at some length upon the general effect of such a tendency upon character as a whole. They admit, however, that the tendency may show itself in a particular situation without being a common feature in all the reactions of a particular subject. The tendency is one meriting more elaborate investigation in all its various forms.

[1] Müller, G. E., und Pilzecker, A., 'Experimentelle Beiträge zur Lehre vom Gedächtnis,' *Zeitschrift für Psychol. und Physiol. der Sinnesorgane*, 1900, Ergänzungsband, I., p. 53 ff.

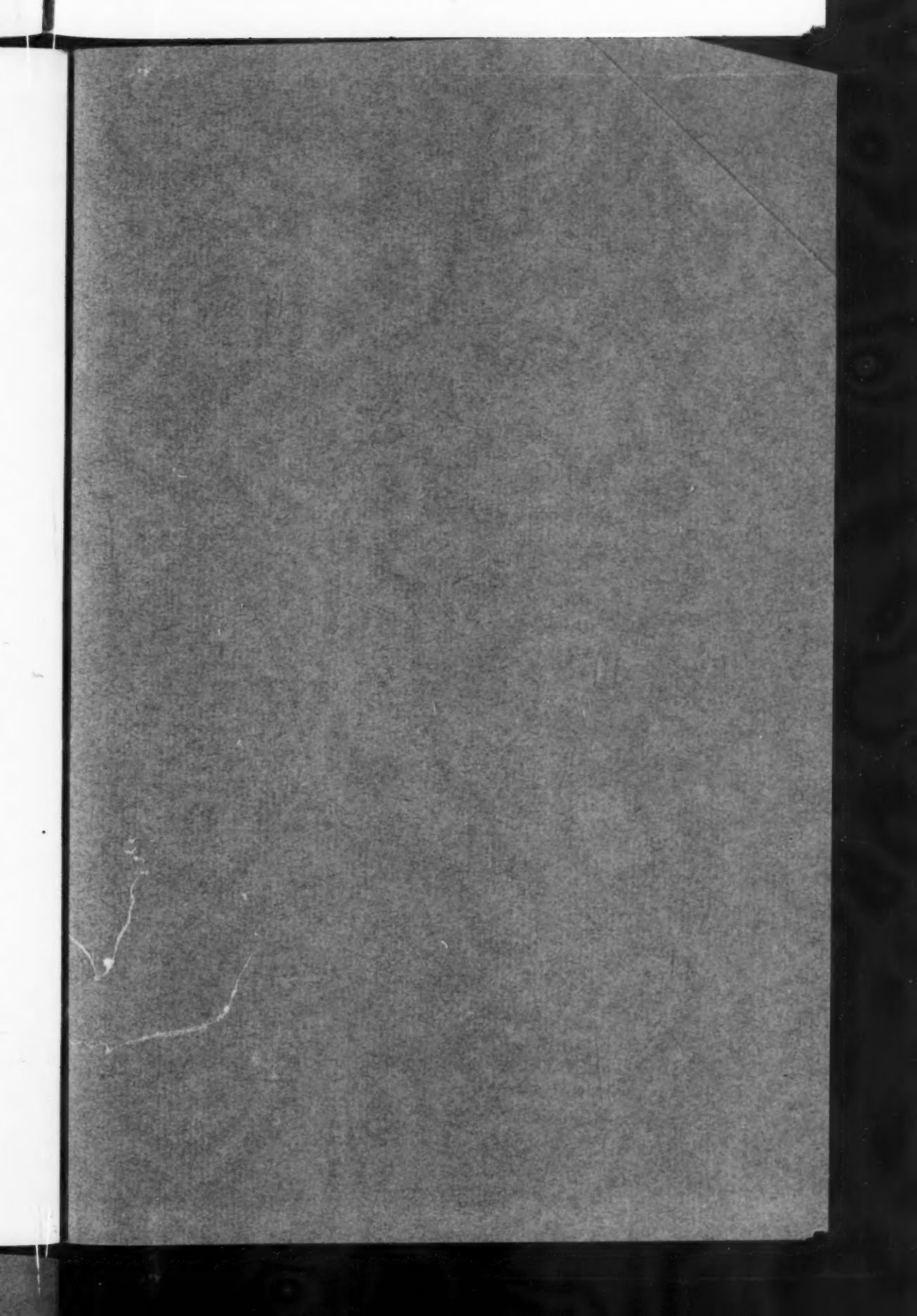
That muscle-reading threw into relief certain peculiarities in imagery type is apparent from the course of the paper and needs no further elaboration at this point.

On the whole, the writer has been greatly impressed with the possibilities muscle-reading affords for certain sorts of investigation. She has been impressed with the exceeding delicacy of the expressive side of the mental life and, above all, impressed with the minimal awareness of the subject as to the nature of such expression.

ANNOUNCEMENT.

During Professor Baldwin's temporary absence in Europe, MSS. for this section of the REVIEW may be sent to Professor John B. Watson, The Johns Hopkins University, Baltimore, Md.

Professor Watson from now on becomes one of the editors of the REVIEW.



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